ENHANCING CAPACITY FOR LOW EMISSION DEVELOPMENT STRATEGIES (EC-LEDS)/ CLEAN ENERGY PROGRAM

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Monitoring Report on the Implementation of City of Tbilisi Sustainable Energy Action Plan

MAY 2016

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ACRONYMS

BAU	Business As Usual
BEI	Baseline Emission Inventory
CDM	Clean Development Mechanism
CH_4	Methane
CO	Carbon oxide
CO_2	Carbon Dioxide
CoM	Covenant of Mayor
EC-LEDS	Enhancing Capacity for Low Emission Development Strategies
GDP	Gross Domestic Product
Gg	Gigagram (10^9g= 10^3t)
GIZ	Die Deutsche Gesellschaft für Internationale Zusammenarbeit) German Society for International Cooperation
HPSL	High-intensity discharge lighting
IPCC	Intergovernmental Panel on Climate Change
JRC	Joint Research Centre of the EU
JSC	Joint Stock Company
LEAP	Long range Energy Alternatives Planning System
LED	Light-emitting Diode
LFG	Landfill Gas
MCF	Methane Correction Factor
MWh	Megawatt/h (10^6 watts/h)
N/A	Not available
NMVOC	Non-Methane Volatile Organic Compound
NO_x	Nitrogen Oxides
Pb	Lead
PM	Particulate Matter
SEAP	Sustainable Energy Action Plan
SMS	Short Message Service
SO_2	Sulfur dioxide
USAID	US Agency for International Development

1. EXECUTIVE SUMMARY

The present document represents monitoring report on the implementation of Sustainable Energy Action Plan (SEAP) for the city of Tbilisi in 2011-2014.

After the general overview of changes which took place in administrative borders, population, employment and living standard of the city during the period of 2009-2014, as well as characterizing the ruling body of Tbilisi and its priorities, the Report briefly summarizes the changes which happened in the energy sector of the city and the results of GHG inventory. It is mentioned that in energy consumption the Transport and Buildings sectors occupy the dominant position, in which during the examined period energy consumption has increased by 40-50% with subsequent growth of emissions. Along with these two sectors energy consumption is discussed for Street Lighting and Solid Waste sectors.

Using the inventory actual data, for the assessment of efficiency of emissions reduction measures, proposed and implemented under the SEAP, the Tbilisi energy system computer model has been created, applied for the projection of baseline scenario. The baseline scenario developed in 2011 was updated in 2014 considering the actual data, allowing more precise determination of real emissions reduction. According to obtained results, after the implementation of different measures the overall decrease in emissions in 2014 made 246 Gg CO_2eq, from which 230 Gg comes to Transport sector and 16 Gg to Buildings sector. Besides, a small amount of emissions is cut up from the Greening sector as well.

In the Greening sector under the SEAP planned measures carbon sequestration was to be increased by 1 100 tC in 2011, although during the monitoring it was revealed that resulting from the actually carried out measures the annual increase made only 360 tC, that was caused by the decrease of green cover by 161 ha.

According to separate sectors, the monitoring results have disclosed the following features.

In the **Transportation sector** the number of public transport passengers in 2009-2014 has increased by 68%, while the number of buses has decreased by 27% and by 51% - the emissions. Similar to this, the overall number of mini-buses has lessened by 38%, and emissions from them – by 21%. The rolling-stock of subway in this period remained constant and, consequently, the energy consumption did not change. During the examined period the public transport subsector has been enlarged by the cable-car (the Rike Park – Narikala Fortress) and the funicular tram line, connecting the city with the Mtatsminda Park, was renovated. In the private passenger car and taxi subsector the number of vehicles has risen by 35% and total emissions – by 29%. Identically, the quantity of private commercial cars has grown by 43% and emissions from them – by 39%. In the Tbilisi City Hall vehicle fleet, due to the transfer to smaller, more different cars, the emissions have decreased by 35%. All in all, total emissions from the city Transport sector augmented by 32% compared to 2009, though in comparison with the baseline scenario has decreased by 250 Gg making 12.6% of baseline emissions from the Transportation sector.

Apart from this, in the reporting period many measures have been undertaken to improve road traffic and infrastructure, among them: The Streetlight Control Center has been set up, many ramps, overpasses, tunnels and roads have been constructed, significantly unloading the traffic at crossroads and freeways, the road cover has been repaired, electronic displays have been mounted on the bus stations, the information on bus routes, stops and schedules has been integrated in the Google system, the cooperation with mass-media has widened, etc.

In the **Building sector** the uncertainties in the accounting of areas and energy consumption have been narrowed. According to specified data during the 2009-2014 period overall consumption of electricity in the Buildings sector has grown up by 22%, while the consumption of natural gas increased by 74%. But on the other hand losses in electric energy and gas distribution networks have decreased by 56.7 and 42.0% respectively. After analyzing the monitoring results main conclusions have been derived, according to which questioning of population are necessary to determine the energy consumption trends and the results of the application of used technologies. At the same time it became obvious that the baseline scenario for the residential sector is to be developed a new, based upon the revised data on energy consumption and the results of EC-LEDS questioning. According to the updated scenario, emissions from the Buildings sector by 2014 made 1 624 Gg. This value corresponds to the reductions, calculated for separate adopted measures. A long list of actions planned within the SEAP for the Buildings sector and the status of their implementation is given, each Activity is discussed in detail with the attained/planned energy saving and potential for emissions reduction.

In the **Street lighting sector** the analysis undertaken during the monitoring process has demonstrated that for the last 5 years (2009-2014) the expenditure of electric power solely on street lighting has actually increased by 24%, as the real increase in the number of streetlights appeared to be higher than planned, although the added lanterns are of lower capacity and they do not vary significantly in types. As to the implemented measures, during 2014 in 150 cupboards the so called "ecosystems" were installed, which stabilize the tension in the grid. By this way in 9 months of 2014 about 983 MWh of energy has been saved.

In summarizing the Tbilisi green cover monitoring results main attention is paid to the analysis of changes which took place during the period of 2009-2014 in green cover. The detailed data on the changes in green cover and their causes according to separate districts of Tbilisi are presented. As it comes from these data, the total decrease of green cover area in the examined span, prompted by different reasons, made 161 ha. The results of inventory, conducted in compliance with the IPCC methodology have indicated that stocks of carbon, deposited in the Tbilisi greenery are increasing annually on the average by 6.3 thousand tC, though due to the decrease in biomass reserve the annual carbon sequestration by 2014 is smaller by 40% compared to 2009 level. To alter this tendency according to the SEAP, the planting of greenery has been undertaken annually within the city limits, resulting in placing of 83 755 trees during the period of 2010-2014. In separate Table the lists of 7 emissions reduction measures implemented in Tbilisi Greening sector is given along with the assessments of sequestered by them amount of carbon, which should reach by 2020 1 100 tC annually.

In the **Solid waste** sector the Tbilisi solid waste disposal sites are reviewed since 1972 up to now. The date on Tbilisi population in 2009-2014 are presented according to the SEAP projection ad the Monitoring Report. In the latter document the annual per capita amount of waste is defined to vary in the range of 306.4-310.6 kg. The comparison of 2014 GHG emissions inventory results for the Waste sector with the baseline scenario has indicated that the emissions calculated in the monitoring period exceed the SEAP projected value by 2.8%. The reason for this difference is linked with the faster growth of actual amount of waste and the use of less specified parameters on waste composition. The instrumental measurements undertaken at the Norio SWDS in 2014 have demonstrated that the methane annual emission from the wells of covered sector could vary in the range of 3.9-5.5 Gg, making on the average 4.7 Gg/yr.

2. INTRODUCTION

2.1. Monitoring Report on the implementation of city of Tbilisi Sustainable Energy Action Plan (SEAP) for 2011-2014

The present document represents the Monitoring Report on the implementation of city of Tbilisi Sustainable Energy Action Plan (SEAP) for the years of 2011-2014.

As it is known, on 30 March 2010 the city of Tbilisi[1] became a subscriber to the EU initiated "Covenant of Mayors"[2] (CoM), thus taking an obligation to reduce the GHG emissions from its territory by at least 20% to 2020[3]. Tbilisi created a precedent which in the following years was shared by other cities of Georgia. Since 2010 up to now addition to Tbilisi Georgia's 9 self-governing cities[4] and 4 municipalities[5] have joined the Covenant of Mayors.

In accordance with the CoM demands, for the efficient implementation of voluntary obligations taken in the frames of CoM Tbilisi in 2011 has developed and submitted to the European Commission the city SEAP[6]. In the preparation of Action Plan the Tbilisi City Hall was assessed by the project "Modern Energy Efficient and Lighting Initiative" executed by the Winrock International under the financial support of USAID. According to the guidelines worked out by the Joint Research Center (JRC) of the European Commission mission[7], the development of SEAP document implies the preparation of Baseline Emission Inventory (BEI) and working out of emissions mitigation Action Plan.

At the initial stage of preparing the mentioned above document in respect to the methodology of baseline inventory assessment and selection of sectors the city of Tbilisi came out with prominent initiative. Considering the strategic vison of country's development it was preconditioned that the country in general and correspondingly its capital are developing intensively, economic activity, GDP and population are growing. Consequently the rising of economy automatically causes the increase in the consumption of resources, among them the energy resources, as the demand on comfort and accordingly its supply are expanding[8]. The decision has been taken on the addition to the JRC methodology of one important component – so called Business As Usual (BAU) Scenario[9], which foresees the growth of energy consumption to 2020 and the development of the city in such a way, that the GHG emissions mitigation policy/measures are not implemented. The mitigation measures presented in the SEAP have been planned just under this scenario relevant to emissions projected for 2020. As to selected sectors, considering the Tbilisi development priority directions, the street lighting, greening and waste sectors were added to the transportation and buildings sectors. JRC has discussed and accepted this methodological amendment. The methodology applied in the Tbilisi SEAP was lately used by other cities as well.

The strategic vision of the SEAP document[10], which was developed according to the mentioned methodology by the Tbilisi City Hall and approved in March 2011 by the City Council has been both the

[1] http://www.covenantofmayors.eu/index_en.html
[2] http://www.covenantofmayors.eu/about/signatories_en.html?city_id=1537
[3] https://en.wikipedia.org/wiki/Greenhouse_gas
[4] Batumi, Kutaisi, Telavi, Gori, Akhaltsikhe, Rustavi, Mtskheta, Zugdidi, Poti.
[5] Tianeti, Kazbegi, Bolnisi and Telavi Municipalities
[6] http://www.covenantofmayors.eu/about/signatories_en.html?city_id=1537&seap; http://remissia.ge/index.php/ka/2014-12-09-16-12-09/seaps
[7] http://www.covenantofmayors.eu/IMG/pdf/seap_guidelines_en-2.pdf
[8] The mentioned judgement consonants with the Environmental Kuznec Curve hypothesis, according to which the environmental conditions worsen till to improve not after which the living conditions start to improve not at the price of harming the natural resources, but in contrary under the state of their enhancement, https://en.wikipedia.org/wiki/Kuznets_curve#Environmental_Kuznets_curve.
[9] http://www.ipcc.ch/ipccreports/tar/wg3/index.php?idp=286
[10] http://www.covenantofmayors.eu/about/signatories_en.html?city_id=1537&seap

reduction of GHG emission sources by 2020 and the increase of natural sinks (the green cover). The document[11] also foresees the retaining of city cultural and historic heritage in the process of its implementation, the involvement of stockholders in the planning and execution process, the raising of citizens' awareness and modification of their behavioral norms.

According to the requirements of CoM and the JRC guidelines after developing the SEAP in the span of 2 years the self-governing entity should prepare the Monitoring Report on the implementation of planned measures and submit this Report to JRC, while after 4 years the inventory of GHG emissions must be performed once again concurrently with the monitoring of undertaken measures.

In the present document just the results of these activities are presented. The outcomes of 2014 inventory are presented by sectors, the status of enacting of planned measures and upshots of their conduction are summarized in a separate chapter while the details are given in sections related to individual sectors.

2.2.Trends of Tbilisi development in 2009-2014

Administrative borders

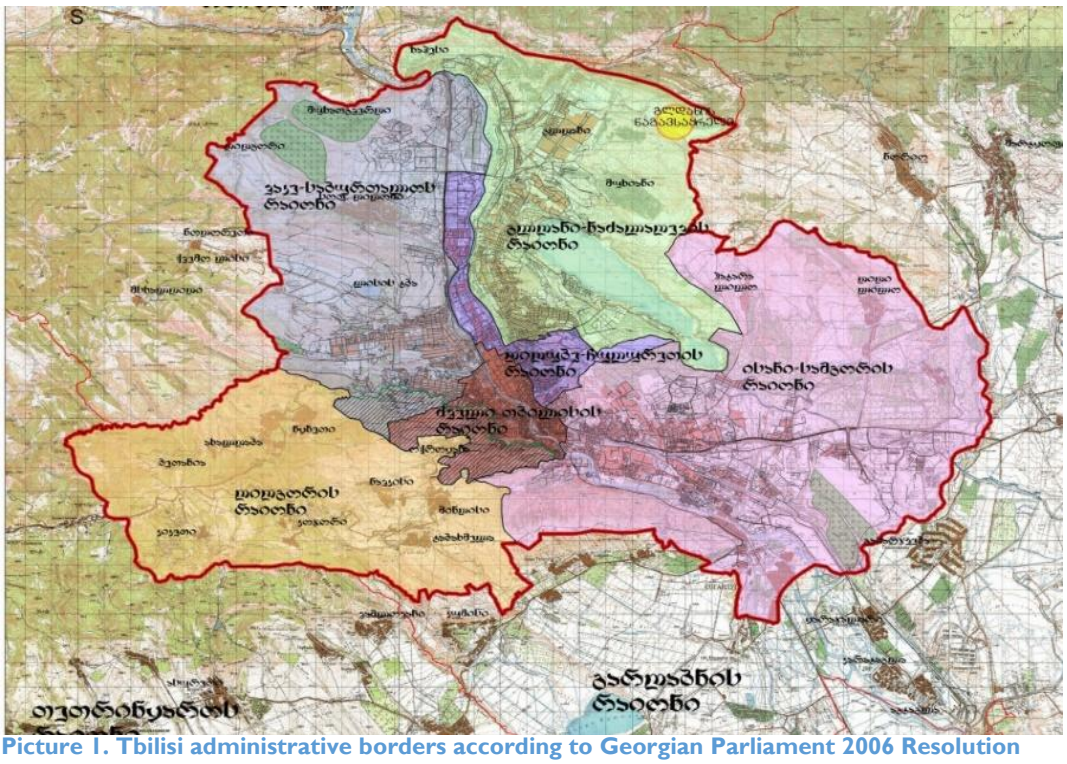
In 2009-2014 the administrative borders of Tbilisi had not changed. According to the Resolution of Georgia's Parliament enacted in 2006[12], the territory of the capital has joined some settlements of Mtskheta and Gardabani Municipalities[13], among them Tabakhmela, Shindisi, Tsavkisi, Kojori, Kiketi, Tskneti, Betania and Akhaldaba settlements. Up to now the Tbilisi administrative territory is divided into 10 districts (Mtatsminda, Vake, Saburtalo, Krtsanisi, Isani, Samgori, Chugureti, Didube, Nadzaladevi and Gldani), which contain 33 different localities, including territories joins under the 2006 Resolution[14].

[11] HOW TO DEVELOP A SUSTAINABLE ENERGY ACTION PLAN (SEAP) IN THE EASTERN PARTNERSHIP AND CENTRAL ASIAN CITIES" – GUIDEBOOK, European Commission Joint Research Centre, Institute for Energy and Transport, Luxembourg: Publications Office of the European Union © European Union, 2013

[12] https://matsne.gov.ge/ka/document/view/44278

[13]

[14] https://matsne.gov.ge/ka/document/view/2602734



Picture 1. Tbilisi administrative borders according to Georgian Parliament 2006 Resolution

Population

Despite the fact that after 2009 the territorial borders of Tbilisi were not altered, the number of population has increased, once more underlining the growing dynamics and trends of Tbilisi as an urban community. According to official statistics data[15] the population of Tbilisi as for 1 January 2014 equaled to 1 175.2 thousand[16], making the 3.4% rise in comparison to 2009 data with 0.67% mean annual increase, being lower the assumed in the Tbilisi SEAP value of 1.1%.

Table 1. Dynamics of number of population in Georgia and Tbilisi in 2009-2014 (thousand persons)

Years	2009	2010	2011	2012	2013	2014
Georgia	4 385.4	4 436.4	4 469.2	4 497.6	4483.8	4490.5
Tbilisi	1 136.6	1 152.5	1 162.4	1 172.7	1171.2	1175.2

Source: National Statistics Service of Georgia

[15] http://www.geostat.ge/?action=page&p_id=151&lang=geo

[16] In November 2014 the population census has been carried out in Georgia, according to preliminary results of which the population of Tbilisi made 1 118 035 persons. However this data was not used in the present Monitoring Report, as its application would cause the necessary of recounting the number of population in the period between the last two censuses, that is not yet competed and the final results will be known after publishing the sequel data (April 2016).

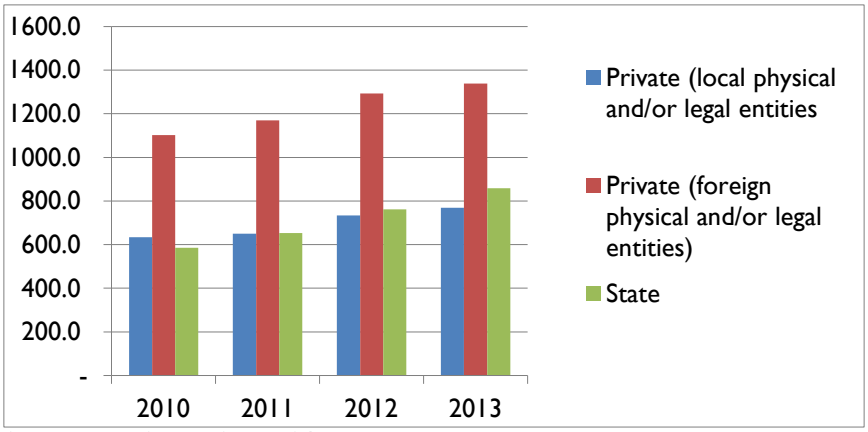
Employment and standard of living

According to official statistics[17], in 2014 41.5% of Tbilisi population were employed giving the 10% in employment compared to 2009 value (37.5%). The dynamics of Tbilisi population employment percentage index in 2009-2014 is presented on Figure 1.

Source: National Statistics Service of Georgia

Figure 1. Percentage index of employment in Tbilisi in 2009-2014.

It has to be noted as well that for the last years the mean monthly salaries of employed persons has increased reflected in the rise of living standard of population. E.g. if in 2011 the monetary and non-monetary means of Tbilisi population were equal to 223 million GEL, by 2014 they amounted to 322.6 million GEL, indicating the 45% growth in this 4-year period[18]. Figure 2 shows the dynamics of the increase of mean monthly salaries during the period of 2010-2013.

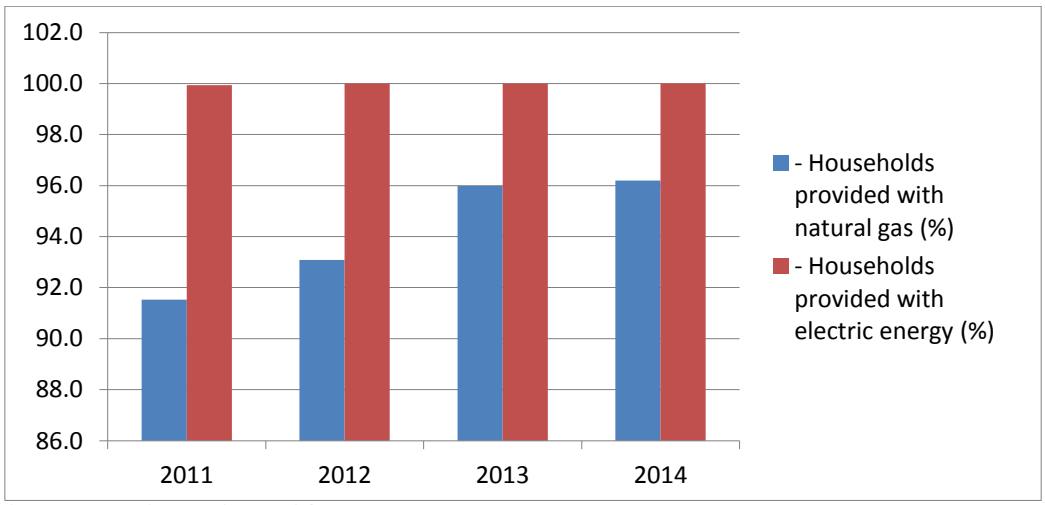


Source: National Statistics Service of Georgia

Figure 2. Mean monthly salary of employees in Tbilisi in 2010-2013

Along with the growth of population and incomes the demand on different services and energy carriers has increased, manifested in the rising dynamics of provision with public utilities. E.g. in 2011 91.5% of households in Tbilisi were supplied with natural gas and by 2014 this number has risen to 96.2%, increasing for its turn the consumption of natural gas all over the city. 100% of Tbilisi households are supplied with electricity (Figure 3).

[17] http://www.geostat.ge/?action=page&p_id=142&lang=geo
[18] http://www.geostat.ge/?action=page&p_id=1201&lang=geo



Source: National Statistics Service of Georgia

Figure 3. Household provided with natural gas and electricity in Tbilisi (%) in 2011-2014

The rising technology is observed in Tbilisi transportation and communications turnover, representing one of the important indexes from the standpoint of city energy consumption monitoring. And as to the construction sector, in 2010-2012 the 185% rise has been registered. The details are given in the graphs below.

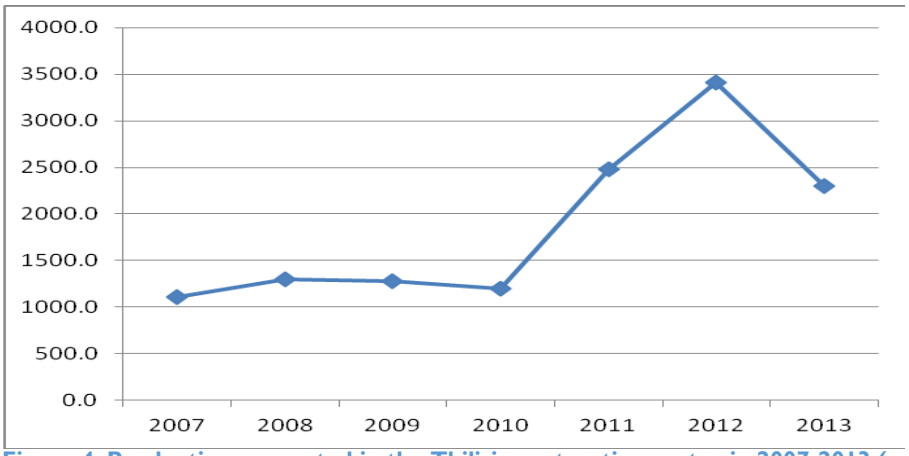


Figure 4. Production generated in the Tbilisi construction sector in 2007-2013 (million GEL)

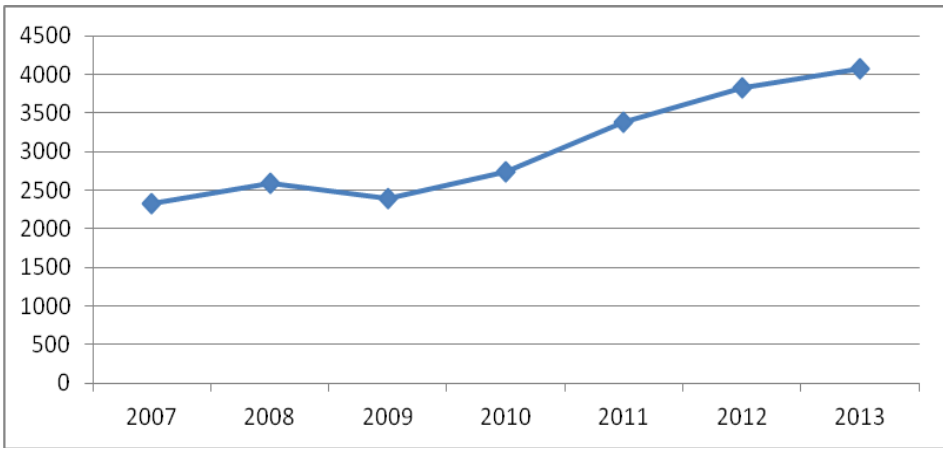


Figure 5. Production generated in the Tbilisi Transport sector and communications in 2007-2013 (million GEL)

The growth dynamics revealed in different sectors of city economy finally has been reflected in the significant growth of city of Tbilisi Gross Domestic Product (GDP). In particular, according to the data of National Statistics Service during the period of 2009-2013 the mean annual growth of GDP by 6.8% has been recorded[19], representing the 2.3% excess rise compared to the assumed in the SEAP value. The details are given in Table 2.

Table 2. The growth of GDP in Tbilisi in 2009-2013

Years	2009	2010	2011	2012	2013	Mean annual growth, %
GDP in current prices, GEL	7 274.3	8 472.6	9 914.3	11 194.2	11 300.9	
Annual growth, %		16%	17%	13%	1%	11.6%
GDP in 2003 fixed prices, GEL	4 887.9	5 242.4	5 602.8	6 261.9	6 366.0	
Annual growth, %		7%	7%	12%	2%	6.8%
Assumption made in Tbilisi SEAP, %		4%	4%	5%	5%	4.5%

All the above mentioned gives a possibility to make some conclusions. In particular, in 2009-2014 as a matter of fact the city of Tbilisi has demonstrated the obvious growth tendency both in the number of population and economic activity as well as in the rise of general standard of life. All these has increased the demand on comfort and different types of resources, among them the energy resources, accompanied by corresponding supplies. Just in this context was going on the implementation of Tbilisi SEAP, connected with the overpassing of several challenges and complications proceed from the fact, that in the process of Tbilisi SEAP development the dynamics of Tbilisi future growth was envisaged at that time and measures were planned relevantly, in spite of energy consumption increase the city managed to attain the % saving of emissions by 2014.

2.3.Governing body of the city of Tbilisi and its priorities

The main responsible body for implementing the Tbilisi SEAP is Tbilisi City Hall[20]. Ensuing from the fact that the Action Plan predicated carrying out of specific measures in different sectors, correspondingly various urban services of the City Hall[21], district administrations, legal Entities of Public Low (LEPLs) and structural units of other type were involved in its execution. The enaction of the plan and its monitoring process is coordinated by the City Hall Economic Policy Urban Service.

In the period of 2009-2014 concerning the institutional arrangement of city self-governing body the important changes were not carried out. Though it should be mentioned that in December 2009 the Tbilisi Architecture Service, being the structural unit of the City Hall, has obtained of the branch, simplify the services, improve the quality and facilitate the introduction of new technologies. In the mentioned body the existing Urban Planning Department was extended by the Urban Development and Management Group, among major functions of which are the urban management of the city and sustainable development that is directly connected with the promotion of successful implementation of the SEAP[22].

As to the encouragement by means of adequate financing of enacting planned measures in the SEAP priority sectors, it could be seen from Table 3 that in 2009-2014 such sectors as putting in order of road paving, the development of urban transportation network, etc. were priority sectors in financing. More detailed information about the expenses spent on emissions reduction measures within each concrete sector, is given in relevant Chapters of the Monitoring Report.

Table 3. Expenses from Tbilisi City Hall budget in 2009-2014

[19] During the development of present Monitoring Report the data on Tbilisi GDP were known only till 2013 (including).
[20] http://new.tbilisi.gov.ge/
[21] http://new.tbilisi.gov.ge/Government/40
[22] http://tas.ge/

Expenses from Tbilisi City Hall budget (GEL)						
Years	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Rehabilitation of road surface	110 734.5	135 910.0	47 106.6	67 173.1	61 297.4	48 629.6
Putting in order the transport infrastructure	12 966.5	5 403 300.0	16 052.0	9 697.8	55 389.9	23 752.9
Greening	7 099.2	12 690.0	11 951.6	14 429.7	12 915.3	12 599.8
City lighting	14 394.0	16 575.0	14 330.9	15 568.7	18 079.4	17 642.5

Source: Website of Tbilisi City Hall[23]

As to the strategic documents worked out and approved in this period, the main objective of which is promoting the sustainable development of the city, the Tbilisi land-use General Plan (Resolution #20-105)[24] has been developed and approved in 2014 by the City Assembly. This document determines main parameters of the use of territories (land-use) and construction activities, providing with good amenities, territorial conditions for the environment and cultural heritage realty protection, transport, engineering and social infrastructure, economic development spatial aspects, as well as territorial problems of setting.

In the end of 2014 the Tbilisi Architectural Service in cooperation with the invited experts has analyzed one more basic document concerning the management of capital's spatial and territorial development – "General Plan of Tbilisi Prospective and Development" approved by the Tbilisi City Assembly in 2009. The analysis has revealed that the mentioned document is not valuable, comprehensive and correspondingly, relevant document for providing the spatial development of the capital in the long-run period. In the General Plan of Tbilisi Prospective Development there is no vision of ways to put into effect the priorities, it does not describe the clear pattern of city development, strategic eyesight of what kind of city should become Tbilisi in future. At the same time the intercoordinated schemes of the development of major urban subsystems – transport and infrastructure are not sufficiently integrated. As far as the mentioned document does not reflect the priorities of city development, the government of Tbilisi has considered as an urgent necessity to develop the General Land-use Plan based upon the new challenges and priorities of territorial spatial development and charged the Tbilisi Architectural Service to announce a competition[25] for the renovation of General Plan.

In 2012 under the assistance of the German Government the GIZ has prepared for the Tbilisi City Hall a technical and economic survey aimed at the setting up of Energy Agency at the City Hall. Though the Energy Agency is not created yet, but in the frame of EU program IOGATE the energy efficiency and renewable technologies information – demonstrative center is established in 2015 at the Tbilisi City Hall. In the long-run perspective this center is planned to be transformed into Energy Agency which at least will coordinate the preparation and implementation of SEAPs as well as the development of new project proposals.

The monitoring has been undertaken on some sustainable development criteria as well, among them the impact of SEAP measures on local pollutants. The results are given in the relevant section of presented document.

[23] http://new.tbilisi.gov.ge/news/1500
[24] https://matsne.gov.ge/ka/document/view/2669598
[25] http://new.tbilisi.gov.ge/news/2472

3. SUMMERY OF MONITORING RESULTS

The base year in the Tbilisi SEAP is 2009, which the monitoring was conducted to2014. The methodology of Energy sector inventory, as well as applied transfer coefficients and emission factors are described in Annex A, and the methodologies used in the Waste and Greening sectors are portrayed in the SEAP and this are not given here.

In the 2011 SEAP the electricity grid emission factor was taken to be 0. 39995 t CO_2eq/MWh, calculated with the CDM methodology. The advantage of this methodology is conditioned by the possibility of its invariable use during the monitoring though, as a rule, it is applied to calculate emissions reduction resulting from separate activities and not in inventory, as in the least case its application could significantly move off the city emissions from the overall emissions of the country. Hence the actual average emission factor is used as well, calculated for each year as a ratio between the total amount of GHG emissions from the county's whole energy generation sector and the total amount of generated electricity. The results of these calculations for the years of 2009 and 2014 given in Table 4.

Table 4. Calculation of electricity average emission factor for 2009 and 2014

Parameter	2009	2014
GHG emissions from electric energy generation, tons CO_2 eq	750	1 080
Total electricity generation, MWh	8 402	10 371
Average emission factor, tCO_2 eq/MWh	0.089	0.104

The use of average emission factor well defines emissions from Tbilisi territory against the background of the whole country as well as makes it possible to compare its emissions with the emissions of other cities. However the application of this factor for the monitoring creates additional difficulty as it varies from year to year and correspondingly affects the annual emissions.

In the present Monitoring Report the inventory was conducted using both the CDM factor and the average emission factor, though in calculating emissions reducting from concrete measures the CDM factor is used.

In Table 5 the energy consumption and GHG emissions in 2009 and 2014 are presented. In 2014 the energy consumption compared to 2009 has increased by 47%, which the emissions have grown by 31%. The most remarkable rise is observed in the Buildings sector. The emissions growth, calculated with the average emission factor is higher, that is caused by the increase of the factor itself.

Table 5. Energy consumption and GHG emissions inventory results in Tbilisi for 2009 and 2014

Sector	Energy consumption (GWh)			Emissions by CDM factor (Gg CO_2 eq)			Emissions by average factor (Gg CO_2 eq)		
	2009	2014	Change (%)	2009	2014	Change (%)	2009	2014	Change (%)
Transport	5 106.73	7 308.21	43	1 309.57	1 729.32	32	1 289.69	1 709.95	33
Buildings	4 021.59	6 101.30	52	1 116.20	1 603.52	44	635.77	1 045.68	64
Street lighting	46.80	51.72	11	18.72	20.68	11	4.18	5.39	29
Solid waste				420.82	461.71	10	420.82	461.71	10
Waste water				155.90	154.45	-1	155.90	154.45	-1
Total	**9 175.12**	**13 461.22**	**47**	**3 021.20**	**3 969.68**	**31**	**2 506.36**	**3 377.18**	**35**

The largest emissions are characterizing the Transport sector, though the percentage share of Buildings sector is also on the rise. It should be mentioned that with the growth of country's electricity grid's average emissions factor (i.e. the more fossil fuel is used to generate electric power), the Buildings sector gains more and more importance as this sector consumers the greatest part of electric energy. Besides, in the Buildings sector important emissions reduction measures are not implemented in contrary to Transportation sector. The share of the Waste sector is also decreased although this is caused not by the introduction of any activity, but by the smaller rate of emissions growth compared to other sectors.

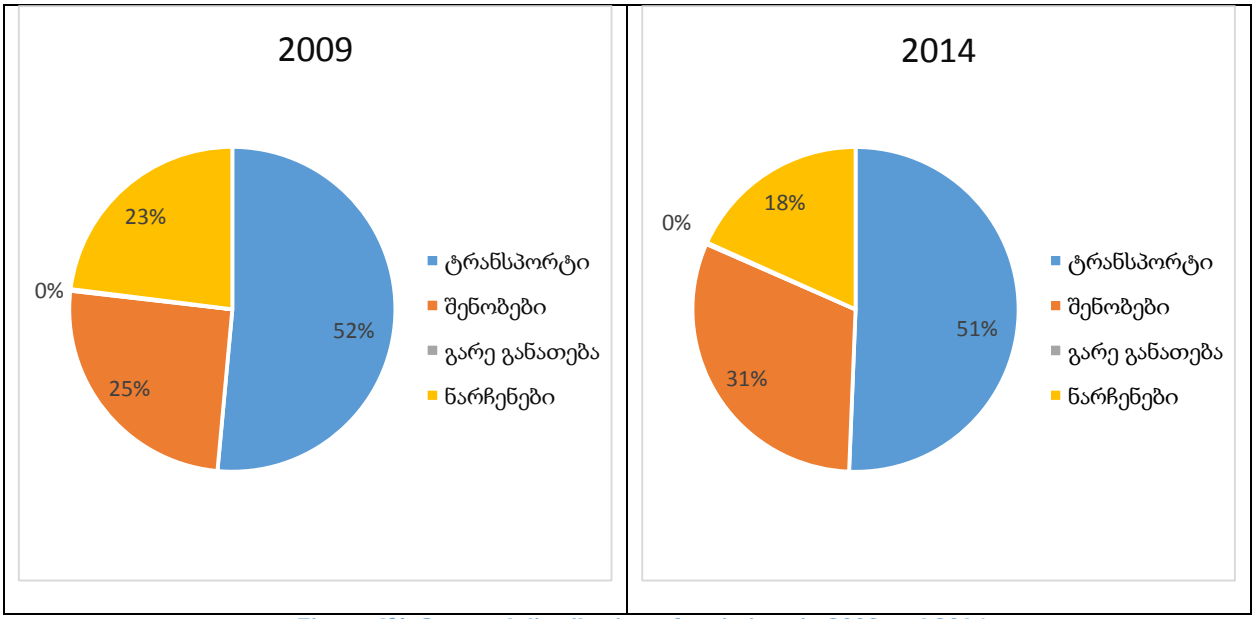


Figure 6[26]. Sectoral distribution of emissions in 2009 and 2014

While developing the Tbilisi 2011 SEAP the computer model of Tbilisi energy system was created using the LEAP program, applied for the projection of baseline (BAU) scenario. The scenario was based upon the forecasted values of Tbilisi economy and population growth. In the process of monitoring, under the consideration of revealed actual changes in economy and population, as well as in trends of energy resources consumption, the baseline scenario was recalculated. At the same time two subsectors were

[26] The average emissions factor for electricity

added to the baseline scenario: "Other commercial buildings" and "Motorcycles", earlier not accounted for. All changes occured to the baseline scenario, are described in Annex B. The 2014 GHG emissions according to baseline scenario are presented in Table 6, along with their reduction considering the 2014 inventory results.

Table 6: GHG emissions reduction in 2014 compared to the baseline scenario

Sector	Emissions by CDM factor (Gg CO_2 eq)		
	Baseline scenario 2014	Actual 2014	Reduction
Transport	1 979	1 729	250
Buildings	1 624	1 604	21
Street lighting	21	21	0
Solid waste	462	462	0
Wastewater	154	154	0
Total	**4 241**	**3 970**	**271**

All in all, according to the inventory results, emissions in 2014 are reduced by 271 Gg compared to the baseline scenario, making 6.4% of baseline emissions. Largest part of reductions (92. 3%) is aatained in the Transportation sector.

According to the assessment of individual activities in separate sectors, the overall reduction appeared to reach 246 Gg CO_2eq (Table 7). The difference between the results of individual activities and the inventory (15 Gg) is caused by the uncertainly of baseline scenario and other external factors (except the activities), affecting the emissions as well. However it should be mentioned that the difference is small and lays within the acceptable limits of uncertainty.

Table 7. Emission reductions resulting from activities in different sectors

Sector	Emission reductions (Gg CO_2 eq)
Transport	230
Buildings	16
Street lighting	0
Solid waste	0
Wastewater	0
Total	**246**

A member of activities were undertaken also in the Greening sector. Analizing the activities envisaged by the 2011 SEAP it could be resumed that almost in all directions they are implemented partially. The exception is planted activity in the Khudadov Forest, enacted in full scale, though without planned extention of forest boundaries. At the same time forested areas have been transferred under the Tbilisi city management where they are almost annually cared of. As to other remaining activities, no measure aimed at the increase of carbon sequestration potential has been realized. In particular, under the planned in 2011 activities the carbon stocks in greenery were to be increased by 1 100 tC annually. However the monitoring results have demonstrated that resulting from the measures taken, the annual increment to carbon stock actually makes only 360 tC being on equivalent to Gg CO_2.

As it could be seen from the monitoring results, the majority of activities is undertaken in the Transport sector.

At this stage it is known as well that in the nearest future other measures will be enacted in transport and street lighting sectors. There are also plans in the conduction of activities in Buildings and Waste sectors. Consequently, it is important to revise the approaches to the implementation of activities in these sectors.

4. TRANSPORT

4.1. Overview of the sector

Since the past centuries Tbilisi is recognized as a center of the South Caucasus Region and its development is one of main priorities and a challenge to the Georgian government. Tbilisi is located in a complex topographical environment of mountains and gorges, on the banks of River Mtkvari, crossing the city and dividing it into two parts. Besides, a number of small tributaries are joining the main river. Parallel to the R. Mtkvari the railway crosses the city. Such environmental conditions greatly affect the city transportation network. Along with the growth of city economy and population the transportation flows are increasing and consequently emerge such serious challenges as the management of traffic jams, air pollution, and provision of comfortable public transport system and arrangement of traffic-free zones.

The Tbilisi SEAP in the Transportation sector considers public transport, provide transport and municipality serving vehicle fleet. In 2010-2014 important measures have been taken aimed at the improvement of public transportation services, infrastructure of streets and management of traffic flows. In this subsection general information is given an innovation and tendencies concerning different types of transport, while the detailed information on carried out measures is presented in the Measures section.

Public transport

The public transport in Tbilisi consists of buses, minibuses, subway and cable-cars. The funicular railway is functioning as well. Out of them buses, metro and cable-cars are managed by Tbilisi Transport Company[27], by 100% owned by the Tbilisi City Hall. This Company operates since 1966 and initially managed only Tbilisi metro. In 2009 under the Decree of Tbilisi City Hall municipal buses and associated with them realty in the form of 3 vehicle parks were transferred to this Company. In 2012 the activity area of TTC has widened and a newly constructed Rike-Narikala cable-car was added to its assets.

The company employs about 5 600 persons working in continuous regime to provide residents of Tbilisi and its guests with high quality services and guarantees of maximum safety and comfort in travel. The slogan of TTC is "**Turn the public transport to the attractive and real alternative to the motor-car"**, being in full compliance with the SEAP position in Transportation sector.

[27] Here and further the information source on Tbilisi Transport Company (TTC) and its transportation units is the TTC web-site (http://ttc.com.ge) and Company's annual report (http://ttc.com.ge/index.php?lang_id=GEO&sec_id=142)

Picture 2. Kinds of public transport under the Tbilisi Transport Company

In 2009-2014 the share of Tbilisi population using the public transport has increased significantly. In particular, in 2014 the number of passengers transported by buses has increased by 113% compared to 2009, passenger turnover of shuttle mini-buses has grown by 40% and that of subway by 25%. At the same time a new cable-car was added, which has transported more than a million passengers in 2014. Detailed information on the number of transported travelers is given in Table 5.

In September 2012 a measure planned under the Tbilisi SEAP has been implemented, according to which the travel tariff reduction system was introduced, allowing the passengers of metro or the bus using plastic cards to take a trip with any transfers for 90 minutes. Correspondingly, as there a less long routs, the number of transfers has risen causing significant increase in passenger turnover, not related with the addition of new passengers. Subtracting from the total turnover passengers engaged in transfers we get 68% increase instead of 113% rise (Table 5). In recent years the free of charge categories have been adopted as well. In 2012 the advanced controllers system has been introduced that helped the company to improve the registration of passengers, being one of the causes of passenger turnover growth.

Unfortunately, despite the increased passenger turnover the number of buses and amount of consumed fuel have not grown. In contrary, the number of buses has decreased. Large DAF type buses were commissioned/written off in the beginning of 2011 due to their absoluteness and technical despair, but the bus fleet has not been filled up, causing the shortening of routs. Main features of Tbilisi bus fleet in 2009 and 2014 are shown in Table 6.

Regrettably, in view of having absolute and curtailed fleet of buses the quality of service offered to passengers is far from desired yet. The decrepitude of vehicles, uncomfortable and overloaded conditions on lines remain the main problem to the public transport. It's impossible to achieve high standard of services without the renovation of vehicles fleet and relevant infrastructure. Ensuing from this the company in cooperation with the City Hall is working on the identification of sources to finance the purchase of new buses in the nearest future.

To provide the safety of public transportation sufficient attention is being paid to the maintenance of buses, quality of purchased spare parts. Drivers employed by the Company are trained before the hiring and the state of their health is annually controlled to provide its compliance with regulations. The bus dispatching office conducts permanent monitoring and control on buses operating in the city. Special internal hot line is operating for drivers. In case of emergency situations dispatchers are ready to respond efficiently.

In 2009-2014 a number of measures were taken to rise the comfort and improve the safety in Tbilisi subway. In the frame of carriage fleet renovation program the modernization of entire rolling-stock of the Company has been completed to 2015 by the company's special repairs plant. This work included both the major repairs of carriages and the installation of modern systems, replacement of internal and external equipment, fitting out of locomotive-driver's cabin with modern control panel.

Table 8 illustrates energy consumption in the Tbilisi metro.

Since 26 June 2012 the Tbilisi public transport network got a new cable-car route joining the Rike Park with the Narikala Fortress. The cable-car line is constructed according to international standards and complies with European safety norms. Its length 500 m and consists of 7 cabins covered with glass and adapted to disabled persons. In 2014 the cable-car has operated for 4 227 hours and consumed 219 800 KWh electric energy.

Along with transportation service the TTC develops information services as well. All bus stations are equipped with digital displays allowing passengers to define exactly the time of suitable bus arrival. The SMS and Internet services are available at the same time. In 2013 up to one million SMS services stops were provided, 46 188 trips were planned and 1 800 bus stops were checked. The information on subway and bus routes, stops and schedules are integrated in the Google Transit System.

As to the shuttle mini-buses, in 2011 a tender has been carried out to select companies operating on the territory of Tbilisi. As a result of this competition the number of mini-buses running in the city has decreased and the routes were specified. The requests stated in the tender concerned the technical condition of the mini-bus, comfort, professional level of drivers, safety, etc. 4 companies were winners of the competition and in 2011 the LLC "Tbilisi Mini-bus" was set-up to manage these 4 companies, which obtained the license to transport passengers within the limits of Tbilisi for the 20-year period.

Since 15 July 2011 Tbilisi population is served by yellow "Ford" mini-buses which are much more comfortable than the mini-buses used before. Initially the mini-buses were requested to provide high standards of comfort (air conditioning) and safety (prohibition of standing travel), but later on the growing passenger turnover and lack of vehicles resulted in the overloading of mini-buses and consequent lowering of demanded standards. In mini-buses both the traditional and plastic card systems of payment are functioning, as well as the use of integrated card, applied in other public transport. Mini-bus routes could be found at the web-site: http://tm.ge//routes/site.php.

Main features of mini-bus fleet in 2009 and 2014 are shown in Table 7. As it could be seen from this Table in recent years the number of shuttle taxis has decreased, though the consumed fuel per one bus has increased. At the same time the shuttle taxis operating on natural gas have appeared. Overall consumption of fuel is reduced.

In the end of 2012 the Telavi funicular has resumed functioning. Its cable railway connects the Chankadze Street with the Mtatsminda Park. For many decades the funicular has been a prominent sight for local population and tourists. The new cable car delivers 60 people in 3 minutes from 460 m up to 727 m a.s.l. The length of the railway equals to 501m. Two carriages are operating simultaneously with function in midway. Both of them are equipped with a number of safety systems providing accidental stopping of the carriage is case of any emergency. In 2014 the tram has served 639 387 passengers consuming in total 645 198 KWh of electricity.

Private transport

The private transport in Tbilisi consists of passenger cars running in the city, taxis (mainly being in private ownership) and commercial vehicles. The rapid development of city economy causes significant increase in the number of all three types of motor-cars. In particular, in the period of 2010-2014 the number of passenger cars (including taxis) has increased by 35% and that of commercial vehicles and trucks – by 43%.

During the mentioned period a number of measures have been undertaken aimed at optimizing the transportation network and improving the road infrastructure. These measures include the arrangement

of traffic lights control system, providing the traffic management and setting up of so called "green waves".

At the same time new roads and tunnels were constructed to provide the unloading of traffic in the Streets, road diving borders have been arranged, etc. However, in spite of these measures the traffic in Tbilisi remains significantly overloaded.

The Tbilisi transport junctions, where the traffic is impeded in rush hours are as follows: Liberty Square, Saakadze streets, crossroads of Beijing and A. Kazbegi streets, as well as:

- Crossroads of Beijing and Tsintsadze streets;
- Overpasses at the Square of Heroes;
- Crossroads of Tamarashvili and University streets;
- Crossroad of Kartozia and Bakhtrioni – Tamarashvili connecting streets;
- Right embankment section from Baratashvili Bridge to Queen Tamar Bridge;
- Melikishvili Square;
- Queen Tamar Avenue;
- Crossroads of Marshal Gelovani Avenue and Sarajishvili streets;
- Vicinities of Metro Station "Akhmeteli";
- Crossroads of Sheshelidze and (ვერ ამოვიკითხე) streets;
- Gelovani Abenue;
- Javakheti Street.

The severe flood and debris-flow of 13 June 2015 seriously damaged the newly constructed Chabua Amirejibi Freeway (SEAP Measure G 2.2) which has not reconstructed yet. The primary goal of this freeway construction was the unloading of Chavchavadze and Beijing streets and hence its fall into disuse will cause the overloading of these streets again.

It should be noted that the hampering of traffic often is caused by the low culture of traffic participants. Both drivers and pedestrians are frequently violating the traffic rules, that negatively affects the movement of transport.

The parking of vehicles at the territory of Tbilisi since 2007 is managed by the LLC "City Park" (CTP). Up to now this is an only company to be responsible for the perfection of parking system in the city. In 2015 the Tbilisi City Hall started negotiations with the company on the banning of parking at the pavements and admission of other companies in this activity, though to the moment of compiling this report the agreement is not achieved.

The parking fee is determined by the Tbilisi government and equals to:

- 50 GEL per annum
- 25 GEL per 6 months
- 4 GEL per 1 week.

The cost was increased in 2010 (till then the annual tax made 25 GEL) accompanied by the expansion of parking places. The dynamics of parking places in Tbilisi shown in

Table 8.

Table 8. Number of parking places in Tbilisi

Year	Number of parking	Among them special places

	places	for disabled persons
2010	16 091	102
2011	34 410	107
2012	36 225	314
2013	33 501	308
2014	33 029	324

As it is seen from the Table, since 2009 number of parking places has increased, but in last years the number has again decreased. This was caused both by the unloading of certain streets and by allowing pedestrians to move freely at the pavements.

One of special features of transport sector in Tbilisi is the significant number of private taxis. Official data on their number is unknown. According to experts assessment the number of taxis in Tbilisi to 2015 exceeded 70 000 and notable increased since 2009. This is caused by the fact that today any person can alter the private car into the taxi without any restrictions from the state. Any driver having the "B" category license can be engaged in the "taxi business". Regulations do not stipulate any form of professional training and even the yellow stencil could be bought by any driver for 40 GEL and more.

In the Tbilisi SEAP, prepared in 2011 no information was provided on the movement of taxis in 2009 as it was not available at that time. Therefore taxis were aggregated with private vehicles and they were assessed by joint questioning. By 2014 the questioning of taxi drivers was undertaken by the EC-LEDS project, aimed at the determination of fuels, fuel consumption and run of the taxis. As to the number of taxis, it was estimated by the expert judgement and numbering of taxis running in the streets because there is no relevant statistics. As a result it was revealed that the majority of taxis (87%) is fueled by natural gas and their age varies in the range of 10-20 years (78%). 16% of cars are older than 20 years and only a small portion is relatively new cars.

Also in 2014 the EC-LEDS project has conducted the questioning of population in 10 cities of Georgia, including Tbilisi. It was derived as a sequel that in 2014 25% of Tbilisi population owned the automobile, suggesting the same data from the Ministry of Internal Affairs. Most widespread types of cars appeared to be Opel, BMW, Mercedes and Toyota. 90% of cars are 10 years of age and more and the majority (57%) is produced in 1995-2005.

Among the fuels gasoline is the most usable fuel (71.1%). The share of natural gas has significantly grown from 2009 to 2014. In that year its share made 26.3%. The diesel fuel is used by only 2.6% of private cars. According to respondents 80% of their run goes to urban areas, where their annual distance coverage is about 10 092 km. Other features are given in Table 11.

The parameters of private passenger cars in 2009 and 2014 are compared in Table 12.

As to the private commercial vehicles, the information on the number of trucks registered in Tbilisi is available in the Ministry of Internal Affairs, though there is no data on their annual run and consumed fuel by types. Hence the assessment are the same, as they were assumed for 2009. This sector requires the substantial additional analysis. The comparison of commercial cars' parameters in 2009 and 2014 is presented in Table 10.

The daily flow of transport coming into Tbilisi from other regions of Georgia should be the subject of additional survey as well.

Municipality owned vehicle fleet

In 2009 at the balance-sheet of Tbilisi City Hall (including district divisions) in total 304 motor-cars were registered. In 2011 the cars were substituted and the City Hall has purchased 210 new vehicles, the majority of which were small-engine cars consuming lower amount of fuel (mainly KIA PICANTO 1.0). As a result the consumption of fuel has decreased and emissions were lowered. Information on vehicle fleet serving the City Hall is given in Table 14, while the measure of car substitution is discussed in detail when describing the relevant measures.

4.2.Parameters under monitoring and methodology

The Tbilisi Transport sector has been monitored according to following parameters:

1. Passenger turnover of public transport;
2. For all vehicle types (bus, mini-bus, private passenger cars, private commercial, municipality-owned vehicles):
    - Number of vehicles by fuel consumed;
    - Average run;
    - Average consumption of fuel per 100 km by fuel types.

On the basis if this information the annual consumption of fuel (by fuel types) and amount of emissions is being calculated;

3. For the electric passenger transport (metro, aerial cable-ways, funicular tram):

    - Electric energy and other fuels (if used) consumption.

Using this information the amount of emissions is described in Appendix A.

The methodology for calculating the amount of emissions is described in Appendix A.

At the same time the information has been collected on the measures implemented, described in the relevant sections of present report.

Passenger turnover of public transport

The passenger turnover of public transport has increased significantly. As it has been explained earlier, this is partly caused by the shortening of routs and introduction of 90-minute free transfers. The data on passenger turnover is presented in Table 9.

Table 9.Passenger turnover of public transport in 2009 and 2014 by transport types

Passenger turnover (passenger per annum)	2009	2014	Increase (%)
Bus	56 900 000	121 261 180	113
Mini-bus	113 800 000	158 916 505	40
Metro	78 300 000	98 981 378	26
Cable car	0	1 026 648	100
Funicular	0	639 387	100
Total	**249 000 000**	**380 825 098**	**53**

Sources: 2009 data (except metro) – The Tbilisi SEAP, 2014 data – Transportation Service of Tbilisi City Hall.

Subtracting in public transport passengers, using the 90-minute transfer (accounting their one trip by two transports as a one trip), their number making 21% of subway and bus passengers, the turnover increase will become 34.4% instead of 53%.

Public transport-buses

In public transport the number of buses in Tbilisi has notably decreased. The annual run and amount of consumed fuel are reduced as well, finally resulting in the lessening of emissions (10).

Table 10. Features of Tbilisi bus fleet, fuel consumption and emissions

Parameter	2009	2014	Increase (%)
Number of buses (all diesel fueled)	934	679	-27
Annual run (m/vehicle)	62 527	59 289	-5
Average fuel consumption by 1 diesel powered bus (l/100km)	34	24	-29
Total fuel consumption – diesel (l)	19 981 054	9 821 054	-51
Total fuel consumption – diesel (MWh)	209 351	102 900	-51
Total emissions – diesel (t CO_2 eq.)	55 400	27 230	-51

Source: 2009 data the Tbilisi SEAP, 2014 data – Transportation Service of Tbilisi City Hall

The Table shows that in public transport subsector the emissions from buses are reduced by 51% compared to 2009.

Public transport – mini-buses

In case of shuttle taxis the number of vehicles and the run are reduced as well, though the fuel consumption on 100 km per one vehicle has risen and 65 mini-buses operating on natural gas are introduced. All these results in 21% cutback of emissions in comparison with the 2009 data (Table 11).

Table 11.Features of Tbilisi mini-bus fleet, fuel consumption and emissions

Parameter	2009	2014	Alteration (%)
Number of vehicles by fuel type			
Operating on diesel	2 621	1 562	-40
Operating on natural gas	0	65	100
Total	2 621	1 627	-38
Annual run (km/vehicle)	80 300	77 127	-4
Average fuel consumption of 1 vehicle on diesel (l/100 km)	12	16	33
Average fuel consumption of 1 vehicle on natural gas (m^3/100km)	-	19	100
Total fuel consumption – diesel (l)	25 255 956	19 275 498	-24
Total fuel consumption – natural gas (m^3)	-	952 514	100
Total fuel consumption – diesel (MWh)	264 619	201 959	-24
Total fuel consumption – natural gas (MWh)	-	8 888	100
Total energy consumption (MWh)	264 619	210 847	-20
Total emissions – diesel (ton CO2 eq.)	71 768	54 774	-24
Total emissions – natural gas (ton CO2 eq.)	-	1 821	100
Total emissions (ton CO2 eq.)	71 768	56 594	-21

Source: 2009 data – the Tbilisi SEAP, 2014 data – Transportation Service of Tbilisi City Hall

Electric Transport

Compared to 2009 the number of metro wagons/carriages has not changed and the carriage fleet equals to 195 units. At present 149 wagons are in operation (among them 145 renovated). Energy consumption in 2009 and 2014 by the metro and cable car is given. Emissions are calculated using emission factor defined by two different methods. First of them is the SEAP value computed under the CDM methodology, equal to 0.399995 ton of CO_2 eq. per each MWh, and the second average emission factor computed annually for the country as the ratio between total GHG emissions from the energy generation sector and total amount of generated electric energy. The calculation of this factor is shown in the Annex A. The energy consumption by Tbilisi metro is given in Table 12.

Table 12. Tbilisi metro wagon fleet, fuel consumption and emissions

	2009	2014	Change %
Total carriage fleet (unit)	195	195	0
Annual run of metro carriages, total (km)	21 460 800	20 640 643	-4
Total fuel consumption – gasoline (l)	38 148	0	-100
Total fuel consumption – diesel (l)	83 322	0	-100
Total consumption – electric energy (MWh)	62 949	64 284	2
Total fuel consumption – gasoline (MWh)	352	0	-100
Total fuel consumption – diesel (MWh)	873	0	-100
The energy consumption (MWh) - gross total	64 174	64 284	0.2
Total emissions – gasoline (ton CO2 eq.)	88	0	-100
Total emissions – diesel (ton CO2 eq.)	231	0	-100
Total emissions – electricity (ton CO2 eq.) by CDM factor	25 176	25 622	2
Total emissions – electricity (ton CO2 eq.) by the average factor	5 619	6 694	19
Total emissions (ton CO2eq.) – by CDM factor	25 495	25 622	1
Total emissions (ton CO2eq.) – by the average factor	5 938	6 694	13

Source: 2009 data – the Tbilisi SEAP, 2014 data – Tbilisi Transport Company (TTC).

Despite the slight decrease in the annual run of carriages, the energy consumption by the metro has increased, that is caused by the growing number of passengers transported. The metro wagons operate on the direct current (4 engines in one train) which is featured by the rising energy consumption with the increase of loading, i.e. the more is number of passengers and, correspondingly, the loading, and the more is the energy, consumed by engines.

Table 13. Electricity consumed by the cable-car and corresponding emissions

Parameter	2014
Total consumption – electricity (MWh)	220
Total emissions (t CO2 eq.) – by CDM factor	88
Total emissions (t CO2 eq.) – by the average factor	23

Source: Tbilisi Transport Company

Table 14. Electricity consumed by funicular and corresponding emissions

Parameter	2014
Total consumption – electricity (MWh)	645
Total emissions (t CO2 eq.) – by CDM factor	258
Total emissions (t CO2 eq.) – by the average factor	67

Source: LLC "Tbilisi Park".

Private passenger cars and taxis

Information concerning private cars and taxis including their numbers, obtained in 2014 under questionings, is compiled in Table 15.

Table 15. Features of private passenger cars and taxis, fuel consumption and emissions in 2014

Parameter	2009	2014	Alteration %
Number of vehicles by fuel type			
Gasoline powered	149 580	5 638	155 218
Diesel powered	17 165	3 993	21 158
Natural gas powered	78 468	60 369	138 837
Total	**245 213**	**70 000**	**315 213**
Average annual run (km/vehicle)	10 100	56 702	
Average gasoline consumption by 1 car (l/100 km)	11	6	
Average diesel consumption by 1 car (l/100 km)	10	7	
Average natural gas consumption by 1 car (l/100 km)	13	7	
Total fuel consumption – gasoline (l)	166 183 302	19 712 345	185 895 647
Total fuel consumption – diesel (l)	17 336 559	15 050 642	32 387 201
Total fuel consumption – natural gas (m^3)	99 066 052	226 211 345	325 277 397
Total fuel consumption – gasoline (MWh)	1 531 345	181 645	1 712 990
Total fuel consumption – diesel (MWh)	181 629	157 680	339 309
Total fuel consumption – natural gas (MWh)	924 341	2 110 678	3 035 019
Total energy consumption (MWh) – gross total	**2 637 315**	**2 450 003**	**5 087 318**
Total emissions – gasoline (t CO2 eq.)	381 257	45 224	426 480
Total emissions – Diesel (t CO2 eq.)	48 068	41 730	89 798
Total emissions – natural gas (t CO2 eq.)	189 344	432 355	621 699
Total emissions (t CO2 eq.)	**618 668**	**519 309**	**1 137 977**

Resulting number of vehicles, fuel consumption and emissions are compared with parallel values in 2009 (**Error! Reference source not found.**).

Table 16. Number of private passenger cars (including taxis) fuel consumption and emissions in 2009 and 2014

Parameter	2009	2014	Alteration %
Number of vehicles by fuel type			
Gasoline powered	221 372	192 280	-13
Diesel powered	10 253	22 065	115
Natural gas powered	1 562	100 868	6358
Total	233 187	315 213	35

Average annual run (km/vehicle)	12 775	10 100	-21
Average gasoline consumption by 1 car (l/100 km)	12.00	11.00	-8
Average diesel consumption by 1 car (l/100 km)	10.00	10.00	0
Average natural gas consumption by 1 car (l/100 km)	10.42	12.50	20
Total fuel consumption – gasoline (l)	339 363 276	213 623 002	-37
Total fuel consumption – diesel (l)	13 098 208	22 285 559	70
Total fuel consumption – natural gas (m^3)	2 079 233	127 346 052	6025
Total fuel consumption – gasoline (MWh)	3 127 413	1 968 649	-37
Total fuel consumption – diesel (MWh)	137 236	233 496	70
Total fuel consumption – natural gas (MWh)	19 753	1 188 304	5916
Total energy consumption (MWh) – gross total	**3 284 402**	**3 390 450**	**3**
Total emissions – gasoline (t CO2 eq.)	778 565	490 092	-37
Total emissions – Diesel (t CO2 eq.)	36 317	61 790	70
Total emissions – natural gas (t CO2 eq.)	4 046	243 395	5916
Total emissions (t CO2 eq.)	**818 927**	**795 277**	**-3**

Source: 2009 data – the Tbilisi SEAP, 2014 data – total number of vehicles – Ministry of Internal Affairs, other parameters EC-LEDS questionings.

As it is seen from the Table, emissions from this subsector have grown by 39%, that, presumably, is caused by remarkable enlargement of taxi fleet. The significant increase in the number of gas-fueled vehicles is also to be mentioned (the gasoline – powered cars are transferred into gas fuel).

In 2014 the motor bikes in Tbilisi have been accounted as well, the total number of which, according to the Ministry of Internal Affairs register, made 2 737 units.

Private commercial vehicles

The survey on private commercial vehicles has not been carried out and only the registration data are available. Hence figures on the run and fuel consumption are taken the same as in 2009.

Table 17. Features of private commercial vehicles, fuel consumption and emissions

Parameter	2009	2014	Alteration %
Number of vehicles by fuel type			
Diesel powered	15 710	21 285	35
Natural gas powered	-	1 120	100
Total	15 710	22 405	43
Annual run (km/vehicle)	30 923	30 923	0
Average diesel consumption by 1 car (l/100 km)	25	25	0
Average natural gas consumption by 1 car (l/100 km)	-	20	100
Total fuel consumption – diesel (l)	121 450 024	164 547 081	35
Total fuel consumption – natural gas (m^3)	-	6 928 298	100
Total fuel consumption – diesel (MWh)	1 272 490	1 724 038	35
Total fuel consumption – natural gas (MWh)	-	64 650	100
Total energy consumption (MWh) – gross total	1 272 490	1 788 688	41
Total emissions – Diesel (t CO2 eq.)	336 737	456 229	35
Total emissions – natural gas (t CO2 eq.)	-	13 242	100
Total emissions (t CO2 eq.)	336 737	469 471	39

Source: 2009 data – the Tbilisi SEAP, 2014 data – total number of vehicles – Ministry of Internal Affairs, other parameters-experts assessments and 2009 Tbilisi SEAP

Tbilisi City Hall serving vehicles

The data on the number and fuel consumption of vehicles providing the Tbilisi City Hall is presented in Table 18.

Table 18. Features of Tbilisi City Hall serving vehicles, fuel consumption and emissions

Parameter	2009	2014	Alteration %
Number of vehicles by fuel type			
Gasoline powered	164	258	57
Diesel powered	140	11	-92
Total	304	269	-12
Annual run (km/vehicle)	33 600	47 113	40
Average gasoline consumption by 1 car (l/100 km)	14	6.50	-54
Average diesel consumption by 1 car (l/100 km)	9	7.85	-16
Total fuel consumption –gasoline (l)	771 456	790 093	2
Total fuel consumption – diesel (l)	438 000	40 663	-91
Total fuel consumption – gasoline (MWh)	7 109	7 281	2
Total fuel consumption – diesel (MWh)	4 589	426	-91
Total energy consumption (MWh) – gross total	**11 699**	**7 707**	**-34**
Total emissions – gasoline (t CO2 eq.)	1 770	1 813	2
Total emissions – diesel (t CO2 eq.)	1 214	113	-91
Total emissions (t CO2 eq.)	**2 984**	**1 925**	**-35**

As it could be seen from the Table, the fuel consumption by serving vehicles has decreased, that is caused by carrying out the adequate measure in 2011, consisting of the substitution of existing vehicles with smaller engine powered cars. The total number of replaced in 2011 automobiles made 210.

4.3.2014 Inventory of Transportation Sector and Correspondence of GHG Emissions with Baseline Scenario

Table 19 demonstrates the aggregated 2009 and 2014 data on energy consumption and GHG emissions from Tbilisi Transport sector. As it is clear from these data, the energy consumption has increased by 43% while the emissions grew only by 32%. This discrepancy is caused by the rise in the share of natural gas powered vehicles.

Table 19. Energy consumption and GHG emissions from the Tbilisi Transport sector in 2009 and 2014.

Category of transport	Energy consumption (GWh)			Emissions (Gg CO2 eq.)		
	2009	2014	Change, %	2009	2014	Change, %
Municipality serving vehicles	11.7	7.7	-34	3.0	1.9	-35
Public transport						
Buses	209.4	102.9	-51	55.4	27.2	-51
Mini-buses	264.6	210.8	-20	70.0	55.3	-21
Electric transport	64.2	65.5	2	25.5* (5.6)**	26.1*	3

					(6.8)**	
Total	**538.1**	**378.3**	**-30**	**150.9**	**108.3**	**-28**
Private transport						
Passenger cars (including taxis)	3284.4	5087.3	55	818.9	1138.0	39
Commercial transport	1272.5	1788.5	41	336.7	469.5	39
Motor-bikes		45.4	100		11.3	100
Total:	4556.9	6921.3	52	1155.7	1618.8	40
Transport – gross total	**5106.7**	**7308.2**	**43**	**1309.6* (1289.7)****	**1729.3* (1710.0)****	**32**

* Calculated using electricity CDM Factor
** Calculated using electricity averaged Factor

According to baseline scenario the emissions increase to 2014 was projected up to 1 830 Gg. The baseline scenario has been updated with the actual data on the number of population and GDP. The motorbikes category has been added to projections, which not planned in 2009 and the elasticity of commercial transport growth has been corrected, which increased in proportions to GDP. In the updated baseline scenario emissions made 1 813 Gg, from which the growth by about 57 tons was conditioned by changes in GDP and rise of population, by 11 tons – with the addition of motorbikes and by 87 tons – by the modification of commercial transport projection.

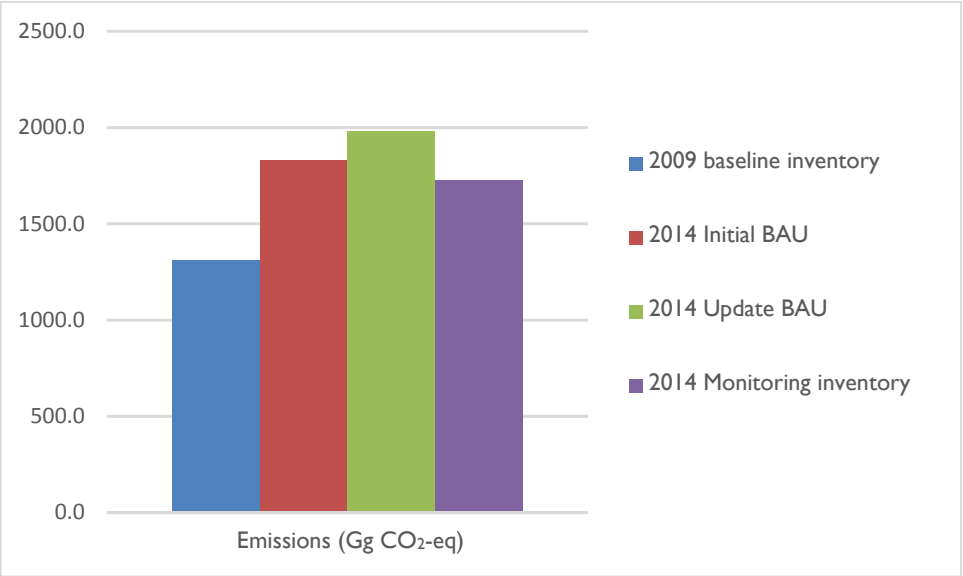


Figure 7. GHG emissions from the Tbilisi Transport sector (Gg CO2 eq.) in 2009 and 2014 according to monitoring results and baseline scenarios.

As it comes from the inventory results, the 2014 emissions compared to the revised baseline scenario are reduced by about 83.4 Gg, being 4.7% of Transportation sector's baseline emissions.

4.4. Emissions Reduction Measures Implemented in the Tbilisi Transportation Sector

In 2010-2014 a number of measures have been implemented in Tbilisi Transportation sector aimed at optimizing the public transport and improvement of road infrastructure. Assessments indicate that these measures have reduced nearly 230 Gg of emissions, being 45.6% of planned in this sector reductions. The difference between emissions reduction obtained by the inventory (250 Gg) and acquired by

application of different measures (230 Gg) is sufficiently small and is caused by other external factors not envisaged in these measures.

In the Table below the measures planned till 2014 in the Tbilisi SEAP are listed and the status of their implementation is defined (**Error! Reference source not found.**).

The assessment of saved energy and relevant reduction of emissions are given in **Error! Reference ource not found.**.

Table 20. Implementation status of measures in the Tbilisi Transport sector

Sector	Major activities	Area of intervention	Tool	Initiator of activity	Responsible agency	Implementing period		Realization status	Spending Up to this stage (GEL)
Transport						**start**	**end**		
Activity MF1	Renovation of municipality vehicle fleet	Clean/efficient vehicles	N/A	Local authority	Tbilisi City Hall administration	2011	2011	Accomplished	
Activity PR 1	Setting up of traffic lights control center	Optimizing road network	N/A	Local authority	Tbilisi City Hall Urban Transport Service	2011	2020	Current	
Activity UP1	Improving the road infrastructure	Optimizing road network	N/A	Local authority	Tbilisi City Hall Transport and infrastructure Urban Services, Tbilisi Development Fund	2010	2015	Current	
Activity PB1	Public transport popularization campaign	Transfer to public transport	Awareness raising	Local authority	Tbilisi City Hall administration/ Public Relations and Marketing Dept. of Tbilisi Transport Company / Media companies	2010	2020	Current	
Activity PB2	Improving public transportation services	Transfer to public transport	Transport regulation	Local authority	Tbilisi City Hall Urban Transport Service / Tbilisi Transport Company/ Media companies	2010	2020	Current	
Activity PB3	Other ways of public transport improvement	Clean/ efficient vehicles	Transport regulation	Local authority	Tbilisi City Hall Urban Transport Service / TTC	2011	2015	Current	
Activity PR2	Carrying out measures to restrict private cars traffic	Transfer to public transport	Different	Local authority	Tbilisi City Hall Urban Transport Service	2015	2020		
Activity PR3	Encouraging low emission vehicles	Clean/ efficient vehicles	Different	Local authority	Tbilisi City Hall Urban Transport Service	2015	2020		
Total									

Table 21. Saved energy and reduced emissions resulting from taken measures

		2014 monitoring results		Assessments for 2020 according to 2011 SEAP	
Sector	**Major**	**Energy Saving resulting from the measure**	**Reduction of CO2 from the measure**	**Saving of energy resulting from the measure MWh/yr.**	**Reduction of CO2 from the measure (t/yr.)**
Transportation					
Activity MF1:	Renovation of municipal vehicle fleet	4 832.61	1 257.67	3 960.00	990.00
Activity PR1:	Setting up of traffic lights Control Centre			491 060.00	123 850.00
Activity UP1:	Improvement of road infrastructure			30 980.00	5.47
Activity PB1:	Public transport popularization campaign	63 000.00	14 000.00	137 690.00	30 540.00
Activity PB2:	Improvement of public transport services	278 207.68	74 274.95	183 590.00	40 720.00
Activity PB3:	Other ways of public transportation improvement	2 614.00	561.00	306 050.00	69 180.00
Activity PR2:	Introduction of measures restricting private cars traffic			271 750.00	60 500.00
Activity PR3:	Encouragement of low emissions vehicles			669 520.00	179 400.00
Total		**348 654.29**	**90 111.62**	**2 094 600.00**	**505 185.47**

Description of Actions

Action MF1 (M1) – Renovation of municipal vehicles (serving cars) fleet

In 2011 Tbilisi City Hall has purchased from the company "KIA Motors Georgia" Ltd. 210 units of new cars and handed over old cars owned by the City Hall. The majority of obtained vehicles were small-capacity Kia Picanto cars. **Error! Reference source not found.** shows the types, number and fuel onsumption of new vehicles acquired in 2011.

Table 22. Municipality serving cars purchased in 2011

Vehicle type	Number	Fuel consumption per 100 km
Kia Picanto 1.0	122	4.4
Kia Rio 1.4	23	4.6
Kia Optima 2.0	18	7.6
Kia cerato 1.6 (Mechanical)	37	6.5
Kia cerato 1.6 (Automated)	5	7.5
Kia sportigi 2.4	2	9.4
Kia cadenza 3.5	1	9.5
Renault Logan Van	1	7.5
Mitsubisi L200	1	10.6
Total	**210**	

Total cost of cars made 4 139 490 GEL, from which part of the cost was covered by the City Hall at the expense of handed over / commissioned old cars.

As a result the average fuel consumption on 100 km per one car has decreased, but the vehicle annual run has increased. In spite of this the summary fuel consumption nevertheless has downsized. In 2014 the City Hall serving cars all in all have consumed 790 093 liters of gasoline and 40 663 liters of diesel, in total 7 703 MWh of energy. Corresponding emissions from this amount of fuel equal to 1 925 t CO_2 eq. (see Table 11). Compared to 2009 the energy consumption has been lowered by 3 992 MWh and the emissions – by 1 059 tons. According to the updated baseline scenario in 2014 energy consumption by this sector made 12 539 MWh with corresponding emissions of 3 201 ton. Consequently, corresponding to baseline scenario the energy consumption is curtailed by 4 832 MWh while the emissions are cut by 1 276 tons.

Action PR1 (G1) – Traffic Lights Control / Management Center

Since 2012 the Traffic Lights Control Center is functioning in Tbilisi being an automated traffic management system (Traffic Control and Management Center) providing the collection of information on the parameters of transportation flows, it's processing and based upon this data – the regulation of traffic currents in the optional regime.

The control system has its peripheral equipment –transport controllers and detectors. The automated system is controlled from the control panel located at the M. Machavariani street (the 112 building).

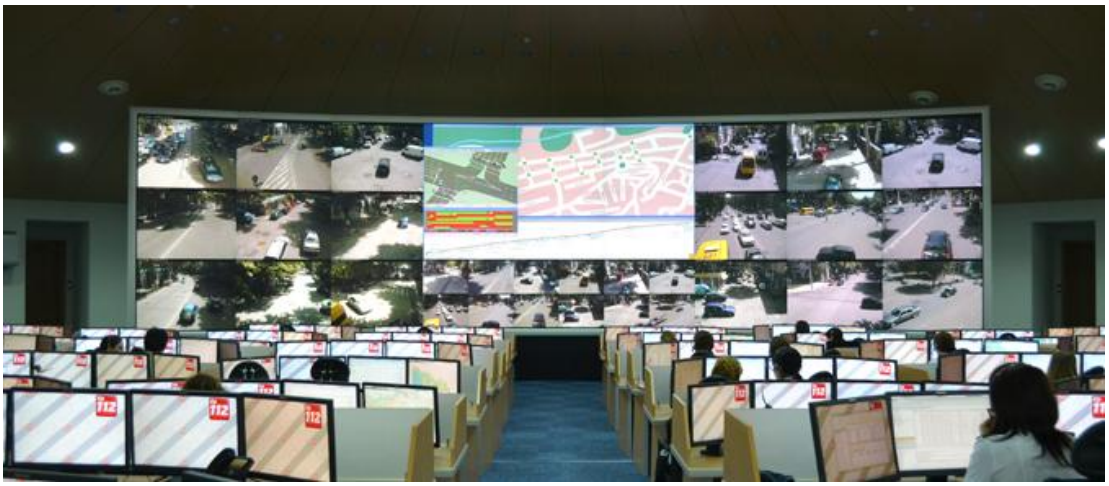
The connection of traffic lights to the Control Center was conducted gradually. At present 121 traffic lights are linked with the control panel (Chavchavadze Ave., Paliashvili st., Abashidze st., Vazha-Pshavela Ave., Al. Kazbegi Ave., Mitskevichi st., Tsintsadze st., Bakhtrioni st., Kavtaradze st., Nutsubidze st., Kandelaki st., Gagarini st., A. Tsereteli Ave., David Curamishvili Ave., Sarajishvili Ave., Dadiani st., Eristavi st., Ketevan Tsamebuli Ave., Lekh Kachinski st., Moscow Ave.).

The function of peripheral equipment is: Assessment of primary information on the parameters of traffic flows; Execution of order from the Control Center; Formation of telemetric signal on the execution of

order and it sending to the Control Centre; Providing of traffic light operation in local regime in case of communication break with the control panel.

Using the traffic lights joined to the traffic automated system it is possible to manage automatically the traffic on the relevant streets and freeways. The automated alteration of traffic light's operation modes (regulation cycle, phase, stroke) allows to reduce to the maximum extent traffic jams, delays at the crossroads, traffic accidents. One of the most important functions of the mentioned system is the coordinated operation of traffic lights (the "green wave").

Total amount of expenditures spent in 2011-2014 on the "installation" of 121 traffic lights and arrangement of traffic control system in the frame of the project implemented in Tbilisi (including video panel mounted in the 112 building, computers and servers) made 13 316 654 GEL.



Picture 3. Tbilisi traffic lights control center.

The realization of GHG emissions reduction potential related with the traffic management (as well as the improvement road infrastructure) is a complicated and contradictory process. The reduction of traffic congestion will decrease GHG emissions from individual vehicles as they will be able to run more efficiently, but this could not necessary bring the lessening of total emissions because the cutback of overloading causes the possibility of running more cars. The moderate speed moving vehicle may be more efficient than the vehicle running in the "stop-start" regime, though the smooth driving may cause the increase in the number of moving cars finally resulting in the net growth of emissions. Hence, if the decrease in the traffic congestion will be accompanied with the restrictions in the use of private cars, the discounting of GHG emissions may be achieved in reality. Mindful of this, the discussed above measures and related emissions reduction could be regarded as a part of broader transportation strategy along with other measures described in this document. The functioning of Streetlight Control Center (along with other measures of that type) causes the rise in the traffic efficiency. To calculate the saving it has been assumed that private vehicles (including taxis) have the same efficiency as in 2009, the energy consumption and GHG emissions were assessed and relative to them the saving was calculated, making about 291.6 GWh and 53.3 Gg of emissions. The impact of these measure has been assessed only for private passenger transport, but for private commercial transport – does not, as the appropriate survey for this type of transport giving on look on the change of its efficiency, is not carried out. It is important for the future to examine and correct the features of commercial transport movement to provide the proper calculation of this measures.

Action UP1 (G2) – Improvement of road infrastructure

In 2009-2014 a number of measures have been undertaken aimed at the planning of new streets and construction of connecting roads and tunnels for the unloading of the traffic and shortening of routs. These are:

- Intense traffic road (Mukhran Machavariani st.): this road offers 2 km shorter route to travel from the Agmashenebeli Movement in the direction of Saburtalo district;
- New road from the Heroes Square (Chabua Amirejibi Freeway): A new 3km long highway has been constructed from the Heroes Square to the Tamarashvili streets, passing 2 800 cars an hour in one direction. The arrangement of this road has significantly unloaded the Chavchavadze and Beijing-Vazha-Pshavela-A.Kazbegi freeways. It has to be noted that the June 2015 flooding has seriously damaged this highway, as a result of which as of August 2015 traffic on this road is impossible;
- Gelovani-Agmashenebli tunnel: In 2011 at the crossroad of Marshal Gelovani and David Agmashenebli Alley the tunnel has been constructed to regulate and unload the traffic (with 2-line traffic from Gelovani to Agmashenebli Alley), which allowed the transport to move freely in any direction without traffic light regulation;
- In 2014 a new 600 m long road was built connecting the Sheshelidze and Gabronidze streets, which allowed the vehicles riding from Sheshelidze st. to Mukhiani Settlement to move freely in the Mukhiani – Temka direction bypassing the Metro Station Akhmeteli and the Theatre. This road has considering discharged the Metro Station Akhmeteli surrounding territory.

Some other measures, not included in the Plan, have been implemented as well. Among the:

- At the right embankment of R. Mtkvari between the Queen Tamar and Baratashvili Bridges a number of activities have been undertaken including: 1) Two overpasses were constructed in the vicinity of Laguna Vere in 2 direction – to the Dighomi District and the Heroe's Square; 2) The driving part has been widened at the expense of sidewalk on the Heidar Aliev embankment (one line was added from the Dry bridge to the Galaktioni Bridge; 3) Near the Galaktioni Bridge from Queen Tamar Bridge to the Baratashvili Bridge the tunnel and overpasses were constructed allowing the unimpeded traffic in this direction, as well as from the Baratashvili Bridge to the Queen Tamar Bridge; 4) In the environs of Baratashvili Bridge and the House of Justice an overpass has been constructed allowing free drive from the Baratashvili Bridge to the Queen Tamar Bridge; 5) The unmounted bridge has been constructed for pedestrians allowing free traffic in this area without traffic lights regulation;
- In 2014 in the vicinity of loaded Metro Station Sarajishvili an overpass has been constructed connecting the Sheshelidze and Sarajishvili streets. It made possible to ride freely from Sheshelidze to the Avchala Settlement and the Kerchi street;
- The Tbilisi Sea Circular Road rehabilitation works have been undertaken (major repairs of the road, mounting of safety fences). The rehabilitation of 10-km Circular Road facilitated the unloading of Tbilisi central freeways. The road is used by vehicles driving from the Gldani – Nadzaladevi District to the Varketili and Lilo Settlements and vice versa.

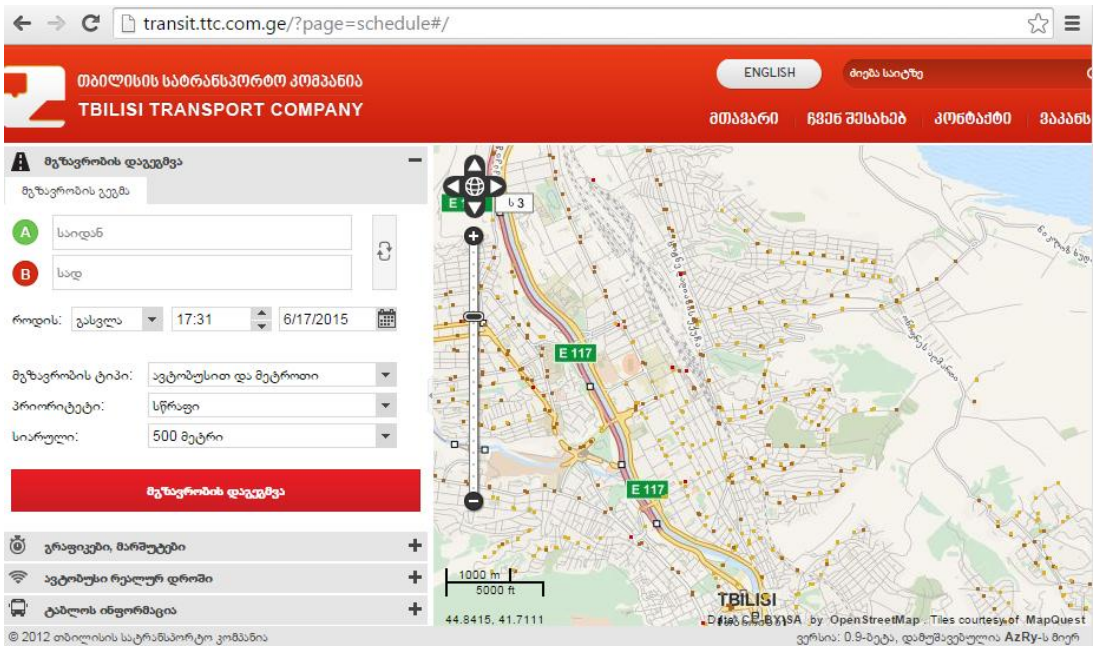
As at this stage no decrease is mentioned in the mean run of vehicles in the private sector (averaged for taxis and private cars), and the cuts related to efficiency are already calculated under the Activity G1, it could be said that no significant cutback is not achieved as a result of this measure.

Action PB1 (Y1) – Public transport popularization campaign

In 2010-2014 the Tbilisi Transport Company (TTC) was actively engaged in the public relations (PR) campaign, including the following activities:

- Improvement of Company's services and introduction of new products;
- Efficient delivery of information to the passengers on innovations and changes taking place in the Company;
- Carrying out of different qualitative surveys, aimed at gathering information on the attitude of passengers to specific items, the analysis and response to this data. In this respect an important part is played by the Company's "Hot line", which registers the remarks and claims of consumers;
- Intensive preparation of materials on different topics to raise the awareness of company personnel and general public on activities and processes going on in the Company.

As it was mentioned above, the residents and guests of Tbilisi already are using the Transportation website (http://ttc.com.ge/), which allows to plan the trip, find the schedules, and watch in real time the movement of the buses, use the SMS service for defining the arrival of the bus at any stop/station. As to the shuttle taxis schedules, they could be found at the "Tbilisi Minibus" website: http://tm.ge/routes/site.php.



Picture 4. Planning of the route with the TTC website.

Besides, the TTC has completed in 2013 the integration in the Google system (Google Transit) of information on the routes, stops and schedules of Tbilisi Metro and buses. For some months this service was tested by the Google that was conditioned by the strict high standards policy of Google. The Google-transit is a part of Google Map project which allows the customer to plan a trip using the public transport. All developed cities of the world are involved in this project and from the beginning of 2014 Tbilisi has joined the list of these cities.

For setting up Transport Company's website in March 2012 two competitions were announced:

- Creation of trip planning program – 14 160 GEL;
- Creation of website design – 15 000 GEL;

The tender for setting up of SMS service software was announced in August 2012, providing 7 000 GEL.

For the integration in the Google system of information about routes, stops and schedules of Tbilisi Subway and buses the Trip Planning Programme has been used, followed by one year active cooperation

with the Google of TTC Information Technologies Service aimed at superimposing of mentioned information on the Google Map without paying additional cost by the Company.

In 2010-2014 the advertisements were broadcast on different TV channels, providing the passengers with the following information:

- On the introduction of new system of paying transport fees in the municipal transport (getting and using of Metro-money cards);
- On the system of discounting fees in the public transport;
- On the improvement of passengers ticketing in municipal buses (the campaigning format);
- On the temporary blocking of some central streets or alteration of bus routes during celebrations or holidays (information lips);
- On the free trips on holidays declared by the City Government (New Year, Easter, Christmas, etc.).

At the same time topics and documental were prepared by a number of TV channels, press and Internet portals about the municipal transport (mainly on Tbilisi Subway).

Under the order of Tbilisi Hall the advertisement campaigns were conducted in 2013-2014 for the TTC aimed at the demonstration of Company in the youth education programs, costing 55 880 GEL.

The effectiveness of this activity could be assessed by the increase of public transport customers, demonstrated in the **Error! Reference source not found.**. According to baseline scenario this ncrease in 2014 was to be about 25%, but actually it made 34%, consequently leading to the cutback of energy consumption in the Transport sector by 165 GWh and emissions reduction by 39.6 tons[28].

Action PB2 (Y2) – Improvement of Public Transport Service

Different measures have been undertaken to improve the public transportation services, among them:

- **Electronic displays**. In 2011 the Tbilisi City Hall started the mounting at the bus stops of modern electronic displays. At present 938 electronic displays are operating in the capital city (initially 950 displays have been installed from which 12 units were damaged). The display allows the passenger to define exactly the arrival time of the necessary route bus and accordingly plan the trip. Electronic displays operate in the online regime and inform the passengers with absolute accuracy on the arrival time of desired bus. The cost of this highly comfortable undertaking realized in 2011-2014, made in total 2 383 145 GEL.
- **New comfortable mini-buses**. In summer 2011 the new "Ford Transit" type mini-buses (equipped with Euro-4 engine) have arrived in Tbilisi. Their services are much better compared to previous ones, but their overloading creates problems which require new planning. The Tbilisi City Hall did not make investments in this direction though the investments by private companies makes about 44 million EURO.
- **Flexible and preferential pay system**. The travel cost can be paid in any public transport using the Metro-money universal plastic card, initially issued in 2006 solely for the use in Subway. Since 2009 its utilization became possible in buses, from 2011-in mini-buses and since 2012 – in cable-car. The city is rich in plastic cards automatic chargers to simplify the filling process. At present the passengers transportation by public transport is regulated with the City

[28] Calculation are performed using the LEAP model

Assembly 30 December 2014 Decree N20-81. The 90 minute privilege / free travel was approved by the City Assembly 27 July 2012 (N 8-30) and came into force 01 August 2012.

- **Safe transportation**. Drivers hired by the TTC, before being allotted to the concrete rout, pass special theoretical and practical training. At the same time the Company provides annual check-up of their health in the frames established by the Low. The safety of mini-bus passengers is protected by operating companies as well as the Transportation Urban Service (Tbilisi City Assembly 30 December 2014 Decree N 20-82). The technical state of vehicles, according to the Low of Georgia on the Road Traffic, is checked twice a year by the Ministry of Internal Affairs Service Agency at the special Maintenance Stations. Besides, daily, after returning from the route, the vehicle undergoes a technical check-up. As to the keeping of traffic rules by the drivers, it is controlled by the Patrol Police.
- **Improvement and optimization of routes**. The design of bus and mini-bus route schemes is determined by the Urban Transport Service. This design is compiled on the basis of population requests' examination and consideration of main passenger flows and traffic safety, being finally presented to the city Government. The decision taken by the City Hall further is submitted to the City Assembly for the follow-up discussion and approval. As it has been mentioned above, the optimization of routes has been enacted in 2010-2014. In particular, till autumn 2009 the 124 bus routes were functioning with 749 daily operating buses. The total number of buses made 932 (among them 241 the "DAF" buses). At present the number of routes has decreased to 97 with 511 daily operating buses. Total listed number of buses equals to 579. As of 2009 the number of shuttle mini-bus routes amounted to 226 and the total number of mini-buses overpassed 3 000 vehicles. To 2015 the number of routes was to reduce to 191 and the number of mini-buses-to 2 000 cars.

In addition to listed above measures the **arrangement of special bus transit lines** was planned to become operational in 2015. This measure is in force up to now.

The discussed above measures are aimed at simplifying the use of public transport and creation of comfort, raising the level of public transport employment. This effect has already calculated in the frame PB1 Activity. At the same time, this activity includes the optimization of vehicle fleet and routes for mini-buses and buses. In 2014 buses and mini-buses have consumed in total 313.7 GWh of energy, correspondingly emitting 82.5 Gg CO_2 eq. (see Table 12). Compared to 2009 the consumption of energy has decreased by 160.2 GWh and emissions have lowered by 42.9 Gg. According to the updated baseline scenario in 2014 the energy consumption for this kind of transportation equaled to 603.2 GWh and the emissions – t 159.8 Gg. Accordingly in comparison with the baseline scenario the energy consumption has downsized by 289.5 GWh, while the emissions have been cut by 77.3 Gg CO_2 eq.

Action PB3 (Y3). Other ways of improving public transportation services

- **Optimization of the bus fleet.** Big and fuel intensive buses were to be removed from the fleet. In 2010 the absolute 241 "DAF" buses were withdrawn from the fleet reducing the energy consumption and emissions. The effect of discounting number of buses has already calculated under the Activity PB1.
- **Extension of Subway to the University Station.** This measure was planned for 2013-2014 but it has not implemented yet. However the fulfillment of this action has already started. In 2015 related with the construction of University Station the Municipal Development Fund has announced the tender. The financial support is provided by the Asia Development Bank. The competition has been won by the Spanish companies "Cobra Instalaciones Y Servicios, S.A" and "Assignia Infraestructuras, S.A". The cost of this undertaking equals to 83 000 670 GEL. The

work has started on 20 June 2015. According to project design putting the station into operation is planned in 24 months after the day of commencing the work.

- **The Tram Line.** This planned project has not implemented yet, however the funicular tram has been put into operation bringing emissions reduction as well because this tram, apart of tourists, is widely used by local population substituting the road transport. In particular, this tram line shortens the road transportation by 5 km. According to 2014 data the funicular tram has been used by 639 387 passengers consuming 645 MWh electric energy with corresponding 258 tons of emissions. In case of using by these passengers the road transport instead of tram (assuming gasoline powered car with 2 passengers on board), the energy consumption would be equal to 3 241 MWh and emissions 807 tons. Consequently, the 2 596 MWh of energy has been saved and 554 tons of emissions reduced (in case of using electricity grid average emission factor, the emissions reduction goes up to 740 t CO_2 eq.).

Besides, since June 2012 the Tbilisi public transport was added with the Rike Park – Narikala Fortress cable car. In contrast to the funicular tram line, this cable-car is mainly oriented on serving the tourists and is not regularly used by city population. Hence, emissions reduction from its operation is not significant.

At the same time a measure has been undertaken consisting of replacing loss efficient lamps with LED bulbs in Tbilisi Subway rolling-stock. In 2013-2014 during the renovation of metro carriages the ЛБ-20 luminescent lamps were substituted by LED lamps. Bulbs were replaced in 20 wagons and 860 lamps were substituted in total with 11 520 LED cells. Actually, the equivalent of 1 old ЛБ-20 type bulb is 13 LED cells.

The capacity of ЛБ-20 bulb is 20 W, while that of equivalent LED cells – 14 W. The aggregated capacity of old bulbs comprised 17.2 KW and that of new ones – 12.2 KW. The daily duration of lighting in carriages is one the average 10 hours, correspondingly the annual saving of energy makes (17.2-12.2) x10x365 = 18 250 KWh and relevant reduction of GHG emissions by 7.3 tons.

Apart of efficiency, the preference of LED cells consists of safety, ecological cleanness and reliability.

In 2010-2014 span 63 wagons have been repaired costing in total 39 816 037 GEL.

All in all, since 2014 in the frames of Activity PB3 2 614 MWh of energy has been saved with related emissions of 554 tons.

The discussed above measures were planned in the Tbilisi SEAP for 2010-2014. At the same time, in the long-run perspective (beginning from 2015), the **Action PR3 (R1) "Private Cars Discouraging Actions"** was envisaged, defined under the long-term strategy. It included measures related with pricing policy for transportation in the center of the city, arrangement of Environmental Islands and the parking policy. No emission reduction activities in these directions were not undertaken in 2010-2014.

Despite the fact that the parking in Tbilisi is managed, the measures directed towards the reduction of emissions (decrease in parking places, substantial increase of parking cost) have not been implemented. As at this stage there is no significant decrease in parking sites (see Table 1) and considerable rise in parking costs, it has been considered that this measure does not initiate the discounting of emissions.

The implementation of **Activity PR4 (R4) – Encouragement of Low Emission Cars.** Since 2009 the number of gas-powered vehicles has increased significantly. For the assessment of impact of transfer to natural gas, the emissions were calculated in case if proportional distribution of private

cars and taxis according to fuel in 2014 would be same as in 2009 and estimates were made of the decrease actual emissions in 2014 compared to this case. The saving has reached to about 58.1 Gg (without actual saving of energy). However, it is to be mentioned that the main stimulus of the transfer to gas is the significant difference in prices between natural gas and other types of fuel (gasoline, diesel), other than some measure. Though the Tbilisi City Hall is again planning to take such measures.

While developing initial version of the SEAP. It was excepted that technical control of motor vehicles would become mandatory beginning from 2015, facilitating the adoption of various stimulant measures, e.g. the replacement of hightly polluting gasoline and diesel driven cars with environmentally clean vehicles. This was to be supplemented by the introduction of other environmentally friend by measures such as establishment of low or zero fees on parking for environmentallyclean vehicles, low tariffs for their technical control, discounting tariffs for taxi drivers operating low-emission cars, etc.

The mandatory technical control of vehicles has been postponed till 2018 that has caused the putting back of the possibility to take measures in this direction as well.

5. BUILDINGS

5.1. Overview of the sector

One of the most important parts of Tbilisi SEAP is the Building sector which includes residential municipal and other commercial buildings (offices, shops, hotels, etc.). The Tbilisi 2011 SEAP covered only residential and municipal buildings as the search of data on other types of buildings created problems both in terms of energy consumption and on space and other important information as well. However, ensuing from the CoM demands, since 2011 the information has been added to the CoM web-page on the consumed energy by other buildings and relevant emissions though in the unspecified form. Consequently, the present Monitoring Report mainly deals with residential and municipal buildings, although at the same time as far as possible the information has been defined more exactly for other types of buildings and data has been searched for on some measures undertaken in them.

Residential buildings

According to the information provided by the Tbilisi City Hall and the Public Register, at present 82 681 residential buildings exist in Tbilisi with the total space area of 33 825 437 m^2. This information is collected by the Public Register on the basis of the Addressing Project results (2011-2012) and does not include the adjoined to Tbilisi in 2006 territories and disposed at them settlements (e.g. Tskneti, Tsavkisi, vil. Phonichala, etc.) embracing additional active dwelling area estimated [29] to be about 450 000 m^2.

The aggregated data on Tbilisi residential buildings are given in Table 23.

Table 23. Data on Tbilisi residential buildings as of 2014[30].

#	Storying of building	Number	Total area, m^2
1	Private houses	68 265	6 706 655
2	2-storey buildings	448	371 624
3	3-storey buildings	408	501 619
4	4-storey buildings	629	1 352 788
5	5-6-storey buildings	1163	3 585 597
6	7-8-storey buildings	1 020	4 379 230
7	7-8-storey buildings	1 562	9 834 019
8	11-12-storey buildings	148	857 005
9	13-14-storey buildings	158	871 367
10	15-16-storey buildings	228	1 453 003
11	17-18-storey buildings	49	376 880
12	19-20-storey buildings	4	36 612
13	Italian yards (multi-storey building), command dwellings barracks, cottages	8599	3 499 038
	Total	**82 681**	**33 825 437**

Source: The Public Register

[29] The estimation is performed by multiplying the number of population at this area (about 5 000 households) by the average dwelling area (90 m^2) in case of private houses.

30 Expert buildings existing at the adjoined in 2006 to Tbilisi territories.

In 2014, in the frames of USAID project EC-LEDS the questioning of population[31] has been conducted, allowing to define approximately the share of actually occupied space ("active area) in dwellings. The results indicated that 82.9% of Tbilisi residents live in apartments and the remaining 17.1% - in private houses. The average area of apartment/flat is 77 m^2 and in private houses – 88 m^2. The actively used by Tbilisi households/families[32] area makes nearly 2.35 million m^2. In the Table below the estimates resulting from the questioning are given.

Table 24. "Active" areas occupied by Tbilisi population

Parameters	Flat	Private house	Total
Number of population (thousand persons)	965.5	207.7	1 173.2
Number of family member	3.85	4.02	
Number of families	250 718	51 735	302 453
Proportion between flats and private houses (%)	83%	17%	
Average dwelling area (m^2)	75.5	87.5	
Total area (m^2)	1 893 2891	4 527 711	23 460 602

Every fifth respondents (19%) was in difficulty to recall the date of building's construction, though as a rule the families predominantly live in houses built in 1951-1990 (57%) while 15% of families live in houses constructed before 1950. The share of families living in newly (after 1990) built houses is only 10%.

Since 2010 the 33% of Tbilisi population replaced the roofing of their houses but the roof cover is not energy efficient. As of 2014 only 2% of population have energy efficient roofs. At the same time 35% of population have substituted windows and as of 2014 44% of population have installed metal-plastic windows. 11% of population suggested they are filling window gaps to lessen the cold air infiltration.

The Tbilisi residents have an access to both electricity and the natural gas. Only a small portion of families (0.3%) are using solar energy and only 3% are using firewood as a source of energy. 78 residential buildings are provided with geothermal hot water – this index is being unchanged since 2009.

As it is mentioned above, the majority of families in Tbilisi are living in flats. Such families often are united in flat-owners cooperatives, being the association of the association of the owners of multi-flat residential and commercial buildings, as well as individual dwelling houses (so called "Italian yards"). According to legislation the owners of 2 or more private neighboring houses can set up voluntary amalgamation, but in reality it happens very rarely.

The relations associated with flat owners cooperatives are controlled by a number of regulations, among them: 1) Low of Georgia "On the flat owner's cooperatives"; 2) Georgia's Civil Code; 3) Low of Georgia "On the Public Register"; 4) Resolution of Tbilisi City Assembly "On the facilitation of flat-owners associations".

31 "EC-LEDS Knowledge, Attitude and Behavior Baseline Survey", USAID's "Enhancing Capacity for Low Emission Development Strategies (EC-LEDS) Clean Energy Program", prepared by Winrock International Georgia, August 2014.

32 Includes the Tbilisi population registered by National Statistics Service. Accordingly this does not include areas occupied by foreign residents or persons arrived from other regions of Georgia.

In accordance with these regulations[33] the Tbilisi City Assembly, City Hall and district administrations permanently are implementing various subsidiary projects in cooperation with flat-owners cooperatives, including: repairing of building's roofs, mounting of entrance doors, repairing of elevators, etc. The execution of these projects is by 50-80% co-financed from the Tbilisi City budget under the decision of district administration. One of such activities is the measure related with the increase of lighting energy efficiency – installation of sensor lighting in entrances which is widely used now in Tbilisi residential buildings.

Municipal buildings

The Tbilisi Municipality and its subsidiary organizations possess up to 350 buildings comprising kindergartens, arts and sporting schools, administrative structures, etc. The list of buildings owned by the Municipality and its affiliated bodies as of 2015 is given in Table 25.

Table 25. List of buildings and premises owned by the Tbilisi Municipality

#	Name of real estate	Number	Area, m^2
1	Buildings in the parks	10	15 112
2	Schools of Arts	26	18 576
3	Museums	14	2 537
4	Theatres	3	5 100
5	Sporting and fitness centers	12	38 342
6	Libraries	42	11 225
7	Medical Service Centers	27	26 763
8	Kindergarten	158	222 090
9	Administrative buildings	14	11 203
10	Different purpose buildings	66	102 704
	Total	372	453 652

This information has been collected under the EC-LEDS project and in some cases may lack completeness, as for some buildings the area could not be defined exactly. By the way, in Tbilisi City Hall there is no department having classified information on the buildings in possession, conducting their registration, planning and controlling different measures related with them. These measures and the management of buildings are carried out chaotically under the initiative and request of agency disposed in it. Unlike other bodies, the organized administration is performed by the Tbilisi Kindergartens Management Agency, Ltd which runs the state Kindergartens in the city. The Agency accounts energy resources consumed in Kindergartens and supervises the repairs activities as well. The energy efficiency measures undertaken in municipal buildings in 2010-2014 are implemented just in Kindergartens.

Other buildings

While running the monitoring process the information has been gathered on other types of buildings being in non-municipal ownership: schools, hospitals and dispensaries. According to the information provided by the Public Register, 371 public schools (total area 362 630 m^2), 203 hospitals (total area 142 113 m^2) and 92 dispensaries/clinics (total area 41 205 m^2) are functioning in Tbilisi. Apart from this there are buildings of other type (mainly private commercial, as well as state owned) the information on which was not available at this stage.

The above mentioned information has been collected according to the findings of Addressing Project results, conducted in Tbilisi in 2011-2012. This does not concern territories adjoined to Tbilisi in 2006 and settlements on them, e.g. Tskneti, Tsavkisi, vil. Phonichala, etc.

[33] Low of Georgia "On the flat owner's cooperatives"

Other than areas, getting an information on electricity consumption in these buildings is also problematic. The Tbilisi electric energy distributor "Telasi" accounts electricity consumption by private commercial and services buildings as well as small producing facilities in one – "commercial" category and thus, the separation out of this of the part belonging to buildings is a difficult task. The Tbilisi City Hall in cooperation with the Ministry of Energy and National Statistics Service is working on the solution of this problem.

5.2. Parameters under monitoring in the Buildings sector and methodology

The monitoring of Tbilisi Buildings sector was undertaken for the following main parameters:

- Consumption of different types of energy in dissimilar types of buildings;
- Areas of Tbilisi buildings;
- Other indexes of energy consumption in Buildings sector.

Energy consumption in Buildings sector

The Tbilisi City Hall in cooperation with the Ministry of Energy of Georgia and EC-LED Project has gathered an information on the consumption in 2010-2014 of energy resources in Tbilisi municipal, residential, commercial and other types of buildings sector, which is necessary to conduct the inventory for the year of monitoring.

The distribution of electric energy at the Tbilisi territory is carried out solely by the company "Telasi" while the natural gas is distributed by 7 companies: "KaztransgasTbilisi" Ltd, "Didi Digomi" Ltd., "Varketili Airi" Ltd, "Energo-kavshiri" Ltd., "Kamari M" Ltd, "Gamma" Ltd and "Taba" Ltd. Among them the largest is "Kaztransgas" which supplies to the remaining companies most part of gas distributed by them. The "Kaztransgas" covers 91.3% of residential customers and 95.6% of non-residential customers.

Table 26 demonstrates the patterns of electricity and gas consumption in Tbilisi buildings in 2009 and 2014 with its growing tendency.

Table 26. Consumption of electric energy and natural gas in the Buildings sector in 2009 and 2014

Buildings' category	Electric energy (MWh)			Natural gas (10^3 m^3)		
	2009	2014	Changes (%)	2009	2014	Changes (%)
Residential sector	798 033	887 738	11	203 572	358 834	76
Municipal buildings sector	11 105	11 188	1	1 180	2 147	82
Other buildings	737 203	986 836	34	55 208	90 814	64
Total	**1 546 341**	**1 885 762**	**22**	**259 959**	**451 795**	**74**

Source: Residential and other buildings – Telasi, Kaztransgas, Ministry of Energy, Municipal buildings – EC-LEDS and City Hall survey.

As it could be seen from the Table, in the residential sector since 2009 till 2014 the consumption of electricity is characterized by small (11%) rise, while the consumption of gas indicated significant (76%) growth, caused by considerable increase of heated areas as a result of installing more heaters or the transfer from firewood heating of space to the gas heating. Unfortunately no information is available on the non-heated areas and the use of firewood in 2009 that would define the reasons for such remarkable rise in gas consumption.

One of external factors that may contribute to the significant mounting of the use of gas is the extension of gas customers. Table 27 shows the change in the number of gas customers and in the consumption of gas per 1 customer, suggesting the rise in consumption by 41%.

Table 27. Number of gas residential customers in 2009 and 2014 and the consumption per 1 customer

Parameter	2009	2014	Changes (%)
Consumption of gas in residential sector (thousand m^3)	203 572	358 834	76.3
Number of gas customers	319 287	399 623	25.2
Gas consumption per 1 customer (m^3/customer)	637.582	898	40.8

Source: Ministry of Energy, Annual Reports of SEMEC, Kaztransgas

Another reason for the growth of gas consumption could be the improvement in the accounting system. Since 2009 the losses of gas and electricity have notably decreased in distribution networks, that includes not only the technical losses but so called "commercial losses" as well. Consequently, it could be supposed that the 2014 consumption data are nearer to actual consumption than it was in 2009.

Table 28. Losses in gas and electricity distribution networks in 2009 and 2014

Losses in distribution networks	2009	2014	Change (%)
Electricity (MWh)	317 166	137 300	-56.7
Gas (thousand m^3)	105 780	61 352	-42.0

Source: Ministry of Energy, Annual Report of SEMEC, Kaztransgas, Telavi web-page

The information on energy consumption in municipal buildings was gathered by the Tbilisi City Hall Economic Policy Service and EC-LEDS Project Team. Energy consumption in different types of municipal buildings in 2009 and 2014 is shown in Table 29, while the energy consumption in other buildings in Table 30.

As it is seen from the Table, for the majority of buildings categories the significant increase in gas consumption is typical, conditioned by the gasification of buildings and the expansion of heated areas. The changes are caused also by the addition of new buildings and the closing of some organizations.

As it was mentioned above, the determination of energy consumption values for "commercial" buildings is a problematic task. This category includes state-owned, non-municipal buildings and private commercial buildings. Considering the Ministry of Energy request the main providing company "Kaztransgas" has singled out commercial buildings data from other consumers' data, from other consumers' data, but in case of "Telasi" such picking out of information was found to be impossible. The "Telasi" company joins all commercial organizations in one category, which includes both buildings and production. Hence the given value of electricity consumption incorporates the use of energy by producing facilities as well.

Presumably, the consumption of firewood and oil products in these buildings took place in 2009, though the information on this item is not available.

Table 29. Energy consumption in different types of municipal buildings in 2009 and 2014

#	Type of buildings	Electric energy (KWh)			Gas (m^3)			Oil products (liter)			Firewood (m^3)		
		2009	2014	Change (%)	2009	2014	Change (%)	2009	2014	Change (%)	2009	2014	Change (%)
1	School of Art	175 295	133 449	-24	132 833	105 988	-20	0	2 907	100	0	0	
2	Museum	283 639	165 635	-42	8 072	16 561	105	0	0		0	0	
3	Theatre	87 847	83 935	-4	4 865	38 771	697	0	0		0	0	
4	Sporting and Fitness centers	1 487 614	2 589 545	74	94 791	416 914	340	0	0		0	0	
5	Libraries	247 363	354 639	43	39 790	23 176	-42	0	0		0	0	
6	Medical Service Centre	1 198 868	696 911	-42	66 940	80 241	20	0	0		0	0	
7	Kindergartens	3 982 339	3 450 839	-13	826 665	1 316 270	59	26 753	0	-100	2 664	0	-100
8	Administration buildings	301 561	829 676	175	0	132 514	100	0	0		0	0	
9	Different intention buildings	3 340 298	2 883 310	-14	5 894	16 994	188	0	0		0	0	
	Total	**11 104 821.91**	**11 187 939.39**	**1**	**1 179 850**	**2 147 429**	**82**	**26753**	**2906.57**	**-89**	**2663.8**	**0**	**-100**

Table 30. Energy consumption in "other" buildings category in 2009 and 2014

Sector	Electricity (MWh)			Natural gas (thousand m^3)[34]		
	2009	2014	Change %	2009	2014	Change %
State (non-municipal) buildings	155 488	109 073	-30	16 034	23 382	46
Private commercial buildings[35]	581 714	877 763	51	39 174	67 432	72
Total	737 203	986 836	34	**55 208**	**90 814**	**64**

Areas of buildings

While working on the present Monitoring Report it was found that these is no single information source possessing the data on Tbilisi existing buildings areas. In 2011-2012 the Public Register has implemented the Addressing Project according to which total area of residential buildings in Tbilisi makes 33.8 million m2 (Table 23) but this value does not include territories adjoined in 2006- Kojori, Tskhneti, etc. where the residential area has to be accounted for. Apart from this the Public Register has an information concerning different types of municipal and commercial areas described in the previous Chapter though this information is incomplete as well. The data on areas as of 2014 is presented in preceding section, however the similar information for 2009 is not available impeding their comparison.

The Statistics Service registers the areas of newly built buildings, the information on which is given in Table 31. Corresponding to this data in 2010-2013 2 462 new buildings were handed over with the total area of 3 169 779 m^2.

Table 31. Number and areas of newly constructed buildings in Tbilisi during 2010-2013

Year	Completed buildings	
	Number	Area, m^2
2010	202	334 684
2011	336	425 669
2012	493	821 126
2013	1 431	1 588 300
Total	**2 462**	**3 169 779**

Source: Statistical Yearbook of Georgia – 2014

Unfortunately, there is no available information on the demolition of buildings allowing to have precise data on the changes in total area of buildings for 2010-2014. There is no official statistical information on "active areas" as well, or the areas which are actually occupied and in which the energy is being consumed.

[34] Data are calculated according "Kaztransgas" information proportionally to the number of non-residential customers.
[35] The "Telasi" "commercial" category.

Other features of energy consumption in Buildings Sector

Besides the observation on buildings fund ad energy consumption, for carrying out the complete monitoring it is important to survey in buildings sector other features of energy consumption allowing to have a look on the habits of energy use and the spread of technologies in this sector.

The questioning[36] of population in the frames of EC-LEDS Project conducted in 2014 made it possible to obtain such information as of 2014, although the same survey has not been undertaken in 2009 hindering the analysis of changes. It is essential to regularly carry out studies of such kind to observe the impact of energy efficiency measures on the consciousness of population as well as on the spread of technologies and habits of energy resources consumption. This information is necessary to adequately plan the activities and assess their effectiveness. Table 32 presents an information about some of the features, while more detailed data on the wide spread technologies is given in the text.

Table 32. Some features of energy consumption in residential sector in 2014

Parameter	2014
Space heating	
Relative number of families without heating	3%
Share of natural gas use in space heating	88%
Share of electricity use in space heating	9%
Application of other energy resources	3%
Water heating	
Relative number of families without hot water supply	11%
Share of natural gas use in hot water supply	84%
Share of electricity use in hot water supply	25%
Application of other energy resources	0.3%

Source: EC-LEDS questioning

Family residing in Tbilisi spends on the average 50 GEL on electricity in winter and 30 GEL in summer. The monthly fee on natural gas consumption varies more widely in the warm and cold seasons, equaling to 20 GEL in summer and rising up to 100 GEL in winter. Natural gas is a primary source of energy in Tbilisi for space heating, hot water supply and cooking, though according to 2014 questioning 3% of population is using the firewood yet. Presumably in 2009 this number was higher.

Only 3% of families in Tbilisi suggest that they have no heating. Supposedly in 2009 the number of such families was bigger. Up to now the most usual way of space heating in one or more rooms is the use of "Karma" type individual gas heaters (74% of families). 23% of families in Tbilisi have an individual centralized heating system, from which 8% are supplied with hot water. It has to be noted that the number of families not heating the entire dwelling area is nearly 63%. The number of families only partially heating the space in 2009 is not known but presumably this number was higher. For Tbilisians the main source of energy for heating is natural gas, but every fifth family uses electricity for heating in addition to the gas. The majority of families operate daily the heating system in the 'on-off" regime lasting on the average for 9 hours. The duration of heating season usually 5-6 months from November to March-April, making on the average 5.4 months.

[36] "EC-LEDS Knowledge, Attitude and Behavior Baseline Survey", USAID's "Enhancing Capacity for Low Emission Development Strategies (EC-LEDS) Clean Energy Program", prepared by Winrock International Georgia, August 2014.

In Tbilisi one of ten families has no hot water supply. In general the main mean for getting the hot water is the individual water heater joined to some taps (that makes 50% of families). 8% of families use joint system of hot heating device connected with one faucet. The main source of energy for water heating is natural gas, but each fourth family uses electricity for heating the water.

For Tbilisi residents almost the sole device for cooking is the gas stove usually connected to the gas net. The majority of population possesses TV set and a fridge. The share of families having washing machine and computer, is also high while other family devices are owned by relatively small portion of population.

The majority of Tbilisians has a fridge, though 16% of them are switching off the device in winter season to save the expenses.

Almost 14% of families are using the air conditioner, while most of them (65%) simultaneously use simple appliances (ventilator and hair-drier) as well. 38% of families own modern split systems for cooling and warming and only 7% use the outdated Soviet air conditioners. Usually the conditioner operates 4 hours a day and cools about 60% of dwelling area.

As to the washing machine it is owned by 86% of families. One third (34%) of families uses it daily and half of them (50%) 2-3 times a week.

On the average, a family in Tbilisi uses 10 lamps. As to the type of bulb, the share of families transferred to new technologies (energy efficient bulbs) is 15%. Nearly 28% of families is using both types of lamps. Majority of families using the energy efficient bulbs are in difficulty to define the type of lamp in use.

Actions monitoring

Apart from basic parameters, the information has been collected on the implemented measures in energy efficiency and use of renewables, and based upon these data the saving in energy consumption and emissions reduction was assessed. The monitoring has embraced Tbilisi multi-apartment residential buildings (according to city districts), Tbilisi public schools, Tbilisi private houses, residential buildings, high schools as well as municipal buildings, including kindergartens and medical facilities.

It should be noted that, except few cases, the monitoring in these buildings was not conducted on a permanent basis and hence, the calculated energy saving and emissions reduction are founded on theoretical computations considering the changes in energy efficiency related with the old and new technologies as well as the heat transfer equation.

The emissions were calculated using the methodology described in Annex A, while calculation of energy saving and emissions reduction for each measure is given in the narrative of this measure.

5.3. The 2014 inventory and comparison of GHG emissions with the baseline scenario

The Table below demonstrates energy consumption and GHG emissions in 2009 and 2014 from Tbilisi residential and municipal buildings sector. Electricity emissions are calculated using 2 emission factors – calculated with CDM methodology and averaged emission factor.

As it could be seen from the Table 33, during the discussed period the energy consumption has risen by 52%, and the emissions by 44%. Using the averaged electricity emission factor the growth of emissions makes even 64%, caused by increase in emission factor value.

Table 33. Energy consumption and GHG emissions in the Buildings sector in 2009 and 2014.

Source of energy	Energy consumption (GWh)			Emissions by CDM Factor ($Gg\ CO_2$ eq.)			Emissions by Averaged Factor ($Gg\ CO_2$ eq.)		
	2009	2014	Change %	2009	2014	Change %	2009	2014	Change %
Residential buildings									
Electricity	798.0	887.7	11	319.2	355.1	11	71.2	92.4	30
Natural gas	1 933.8	3 348.1	73	389.6	674.5	73	389.6	674.5	73
Total	**2 731.8**	**4 235.9**	**55**	**708.8**	**1 029.6**	**45**	**460.8**	**767.0**	**66**
Municipal buildings									
Electricity	11.1	11.2	1	4.4	4.5	1	1.0	1.2	18
Natural gas	11.2	20.0	79	2.3	4.0	79	2.3	4.0	79
Firewood	5.5	0.00	-100	0.2	0.0	-100	0.2	0.0	-100
Oil products	0.3	0.03	-89	0.1	0.0	-89	0.1	0.0	-89
Total	**28.1**	**31.3**	**11**	**6.9**	**8.5**	**23**	**3.5**	**5.2**	**50**
Other buildings									
Electricity	737.2	986.8	34	294.8	394.7	34	65.8	102.8	56
Natural gas	524.4	847.3	62	105.7	170.7	62	105.7	170.7	62
Total	**1261.6**	**1834.2**	45	**400.5**	**565.4**	41	**171.5**	**273.5**	59
Buildings Gross total	**4021.6**	**6101.3**	**52**	**1116.2**	**1603.5**	**44**	**635.8**	**1045.7**	**64**

In the 2011 Tbilisi SEAP baseline scenario the emissions from Buildings sector were projected to be equal to 832 Gg (by the CDM factor), being much smaller than the actual 2014 emissions. The reason for this is that the baseline scenario did not include the "Other buildings" category, added in 2014 with its emissions value of 565.4 Gg. At the same time the emissions growth rate in residential sector was projected lower that the actual one. As it was mentioned above, this growth is conditioned mainly by the increase in gas consumption, reaching almost 76%, while the electricity consumption has risen by only 11%. The intensification of gas consumption is related with the growing energy consumption for space heating and hot water supply exceeding the planned value (energy for cooking, as a rule, does not increase significantly). The reasons for the growth could be several, among them:

1. While developing the 2011 SEAP, the information was not available on dwelling areas without heating or hot water supply. Correspondingly, the application of heating and hot water supply systems has not been modelled in these dwellings;
2. Presumably, since 2009 the firewood has been substituted by natural gas. However, due to the lack of information on firewood consumption it was not reflected in the 2011 SEAP inventory. Accordingly, the transfer from firewood consumption to natural gas was not projected in the baseline scenario, significantly increasing the consumption of gas;
3. Supposedly, the heated areas in houses have expanded more rapidly than it was projected (the elasticity per capita in relation to GDP equal to 1);
4. The share of population using natural gas for heating the water has significantly increased (84% in 2014, while in the model this value was assumed to be 70%);

Main conclusion which could be drown from this analysis are as follows:

1. The permanent monitoring of residential buildings and regular questioning of population are necessary to have a right look on energy consumption trends and the results of applied technologies. This will decrease the uncertainty during the monitoring process and in developing the baseline scenario as well;
2. The revealed significant discrepancies between model results and actual data obviously makes it necessary to develop new baseline scenario for the Residential sector, based upon the renovated data on energy consumption and EC-LEDS questioning results;

Accordingly, ensuring from the necessity of renewing the monitoring and Action Plan, the updating of baseline scenario has been performed. In particular:

- The projected values GDP and the number of population were substituted by actual values for 2010-2014;
- The "Other-commercial buildings" category has been added which previously was not accounted for;
- In municipal buildings category the 2009 data has been added on firewood and diesel consumption and projected data on gasification till 2014 were replaced with real data;
- The projected number of gas customers in residential buildings for 2010-2014 has been corrected using actual data and the elasticity of gas heating of space has increased from 0.4 and 1 for bringing the rate of gas heated areas increase nearer to reality. The share of population using natural gas for water heating has increased to 84% by 2014;

Correspondingly has been modified the baseline scenario, according to which the emissions from the Buildings sector in 2014 made 1 624 Gg (with CDM factor) bringing relevant reduction by about 20 Gg. That is in a good agreement with the reduction value, obtained by summarizing specific reductions achieved in implementing individual measures.

5.4. GHG emissions reduction measures implemented in Tbilisi Buildings sector

According to the Tbilisi SEAP Buildings sector short-term strategy at the initial stage energy efficiency measures were to be carried out in municipal buildings. In line with this strategy a number of measures have been undertaken in kindergartens; they are: mounting of centralized heating systems, installation of energy efficient bulbs, setting up solar water heaters, replacement of windows and equipment of pilot building, getting heat and hot water from the heat pump (details see in the description of activities).

In line with the medium-range strategy a number of measures were to be implemented in the residential sector. In particular, the Tbilisi City Hall in this direction has installed so called "sensor" lighting in the entrances of multi-apartment buildings, described in detail in the section of relevant Activities. During this period the population actively replaced the old wooden windows with new efficient metal-plastic ones. Besides, new solar water heaters have been mounted.

At the same time, the City Hall has executed a pilot project in the building 20, section 5, the Temka micro-district 3, Tbilisi. In particular, the heat supply of the building has been provided with common heat generator, placed at the rooftop of the building. For the counting of heat supply the heat meters were installed in each apartment. Along with heat generator 23 blocks of vacuum-pipe solar collector

with total area of 95 m^2 were mounted at the roof as well to provide hot water supply. Aimed at energy saving the double metal-plastic window-frames were installed with the total area of 272 m^2. The building has been divided into 2 parts (blocks A and B). In the block A the external walls, ceiling and the floor (from the basement side) were thermally insulated, while in the block B – were not. This was done to define the share of thermal insulation measures in saving the energy consumption.

Picture 5. The pilot residential building

According to the Tbilisi 2011 SEAP 188.9 Gg of emissions should be saved annually from the Buildings sector by 2020. In 2014 the saving equaled to 16 Gg, being only 8.5% of the planned value. Moreover, compared to the baseline scenario emissions, this 16 Gg makes only 1%, indicating the need for more activities in this field and the necessity of new approaches in planning the appropriate measures.

In the Table below the measures foreseen in the Tbilisi SEAP and the status of their implementation are listed as well as the results of 2014 monitoring on energy saving and emissions reduction.

Table 34. Status of implementing the measures in the Buildings sector

Sector	Key Activities	Sphere of interference	Instrument	Instigator of activity	Responsible body/ agency	Implementing period		Implementation status	Expenses at the stage (GEL)
						Start	End		
Municipal buildings (MB)									
Activity MB1	Installation of space heating systems in municipal buildings	Energy efficiency in heating systems	Energy management	Local Authority	Tbilisi Kindergartens Management Agency	2010	2020	Current	
Activity MB 2	Installation of efficient lighting systems in municipal buildings	Energy efficient lighting	Energy management	Local Authority	Tbilisi Kindergartens Management Agency	2010	2020	Current	57 360
Activity MB 3	Renovation of municipal buildings	Buildings envelope	Energy management	Local Authority	Tbilisi Kindergartens Management Agency	2010	2020	Current	2 880 000
Activity MB 4	Application of renewable energy resources in hot water-supply	Renewable energy for heat and hot water supply	Energy management	Local Authority	Tbilisi Kindergartens Management Agency	2010	2020	Current	15 480
Activity MB 5	Education/ Information /Awareness raising campaign	Behavioral changes	Awareness raising / Training	Local Authority	City Hall Economic Policy Urban Service	2012	2020	Not started	
Activity MB 6	Implementing Energy Management and Monitoring Program in municipal buildings	Behavioral changes	Awareness raising / Training	Local Authority	City Hall Economic Policy Urban Service	2012	2020	Not started	
Residential Buildings (RB)									
Activity RB 1	Mounting of central heating system in residential buildings	Renewable energy for heat and hot water supply	Grants and subsides	Local Authority	City Hall Economic Policy Urban Service	2015	2020	Not started	
Activity RB 2	Installation of efficient lighting systems	Energy efficient lighting	Grants and subsides	Local Authority	Tbilisi City Hall District Authorities	2010	2020	Current	36 625
Activity RB 3	Renovation of residential buildings	Building Envelope	Funding from other sources	Other	Other	2013	2020	Current	
Activity RB 4	Application of renewable energy resources in hot water-supply	Renewable energy for heat and hot water supply	Funding from other sources	Other	Other	2013	2020	Current	
Activity RB 5	Public Awareness raising/ Information campaign	Behavioral changes	Awareness raising / Training	Local Authority	City Hall Economic Policy Urban Service			Not started	

Activity RB 6	Low energy consumption building / Pilot project	Integrated actions	Grants and subsides	Local Authority	Tbilisi City Hall Economic Policy Agency	2013	2020	Current	620 000
Other buildings (OB)									
Activity OB 1	Renovation of Tbilisi schools	Energy efficiency in heating systems	Energy management	Other	Ministry of Education and Science of Georgia	2010	2014	Current	
Activity OB 2	Renewable energy application and energy efficiency pilot projects in different state and commercial buildings	Different	Funding from other sources	Other	Different	2010	2020	Current	
Total									**3 609 465**

Table 35. Energy and emissions saved with actions in the Buildings sector

		2014 Monitoring Results			2020 Assessments from 2011 SEAP		
Sector	**Key Actions**	**Energy saving by the action (MWh/yr.)**	**Renewable energy from the action (MWh/yr.)**	**CO_2 reduction by the action (t/yr.)**	**Energy saving by the action (MWh/yr.)**	**Renewable energy from the action (MWh/yr.)**	**CO_2 reduction by the action (t/yr.)**
Municipal buildings (MB)							
Activity MB1	Installation of space heating systems in municipal buildings	272		50	1 055	6 305.3	1482.9
Activity MB 2	Installation of efficient lighting systems in municipal buildings	791		316	1 148		448
Activity MB 3	Renovation of municipal buildings	2 243		456	3 643		754
Activity MB 4	Application of renewable energy resources in hot water-supply		18	4		189	37.8
Activity MB 5	Education/ Information /Awareness raising campaign				1 287		260
Activity MB 6	Implementing Energy Management and Monitoring Program in municipal buildings						1 850
Residential Buildings (RB)							

Activity RB 1	Mounting of central heating system in residential buildings					57 200.7	11 506.37
Activity RB 2	Installation of efficient lighting systems	7 869		3 147	29 410	0	11 730
Activity RB 3	Renovation of residential buildings	46 853		9 464	698 381		141 659.6
Activity RB 4	Application of renewable energy resources in hot water-supply		525	106		1 050	210
Activity RB 5	Public Awareness raising/ Information campaign				90 332		18 247
Activity RB 6	Low energy consumption building / Pilot project	162		33			
Other buildings (OB)							
Activity OB 1	Renovation of Tbilisi schools	10 532		2 180			
Activity OB 2	Renewable energy application and energy efficiency pilot projects in different state and commercial buildings	1 318	43	252			
Total		**70 040**	**586**	**16 008**	**825 255**	**64 745**	**188 185**

Description of implemented actions/measures

Activity MB1. Installation of space heating systems in municipal buildings. The following measures have been implemented:

MB1. 1. Installation of equipped with local boilers heating systems operating on natural gas.

According to the SEAP the mounting of central heating systems has been planned in at least 20 municipal buildings in the meantime not equipped with the up-to-date heating systems operating on natural gas.

In 2010-2014 central heating systems have been installed in 39 kindergartens. The saving of energy at these facilities is conditioned by the high efficiency (90%) of modern water heating boilers running natural gas, exceeding in efficiency the "Karma" type gas heaters (85%), widespread in Tbilisi municipal buildings. By the introduction of high efficiency heating systems functioning on natural gas, annually has been saved 28 597 m^3 of gas and the reduction of CO_2 emission made about 50 tons.

Activity MB2. Installation of efficient lighting systems in municipal buildings that included the following measures:

MB2.1. Lighting system with fluorescent bulbs

Under this measure at least 30 municipal buildings had to be equipped with energy efficient lighting system instead of incandescent bulbs.

Resulting from the adoption of infrastructural measures in Tbilisi Kindergartens the energy efficient lamps are used in 113 kindergartens. Total number of these lamps makes 7 170. With the introduction of this measure 791 MWh of electric energy has been saved annually, while the CO_2 emission was reduced by 316 tons[37]. The energy saving potential has been defined by comparing the incandescent bulb lighting system efficiency with that of energy efficient bulbs. The expenses allotted for this measure by the City Hall amounted to about 57 360 GEL.

Activity MB3. "Renovation of municipal buildings" has not been implemented in the planned format, however a new measure has been enacted:

MB3.1 – Renovation of windows in kindergarten

The conduction of infrastructural measures through 2010-2014 in Tbilisi Kindergartens has resulted in the replacement of wooden doors and windows by metal-plastic ones in 107 kindergartens. The total area of metal-plastic doors and windows is 24 750 m^2. The energy saving by this measure made 2 183 MWh annually[38], and the reduction of CO_2 emission has reached nearly 441 tons. The Municipality has spent about 2 722 500 GEL on this measure.

At the same time the Activity MB 3.2 (RB6) "Low energy consumption building / Pilot project" has been implemented, in the frames of which the following measures were undertaken in Tbilisi #155 kindergarten: the central heating and hot water-supply systems were assembled based upon the heat pump and external walls of the building were covered with special insulating paint. In 2011 the consumed electric energy was equal to 5 979 KWh, and the gas – 59 859 KWh, while in 2014 the consumed electricity made 43 431 KWh and the gas – 30 052 KWh.

[37] Here and further in assessing the measures, for the electricity emission factor is used the value, calculated under the CDM methodology
[38] The Heat Transfer equation has been used to assess the energy saving obtained under this measure.

This means that the gas has been saved by 29 807 KWh / yr., corresponding to 6 tCO_2/yr. emission. As to electricity, the overspending, in contrast, made 37 452 KWh/yr. relevant to 5.1 t/yr. emission. Consequently, the saving in emission compared to 2009 makes only 0.9 tons. Here it should be taken into account that till the installation of the heat pump (summer 2012) the building was heated partially by gas stoves in separate rooms, while after the mounting of heat pump it is heated completely and at the same time it uses the heat pump for hot water supply. Hence, to calculate the saving the baseline scenario must be accounted for, according to which the building was to be heated entirely and the saving should be calculated relative to this condition. In this case the total energy consumption would be about 133.2 MWh (115.9 MWh for gas and 17.3 MWh for electricity), according to 25.8 tons of emission, while the use of heat pump provides the saving of 14.7 tons of emission.

The activity was conducted in the frame of USAID funded project "New Applied Technology Efficiency and Lighting Initiative (NATELI)", performed by the Winrock International. The implementation of the project costed 90 000 USD (about 157 500 GEL).

Activity MB4. "Application of renewable energy resources in hot water supply" implying the installation of solar collectors in sporting schools and hospitals, has not been realized, however solar collectors were mounted in kindergartens.

Activity MB4.3. Application of solar collectors in kindergartens.

In 2010-2014, resulting from the infrastructural measures undertaken in Tbilisi kindergartens, the solar energy saving system has been introduced in 3 kindergartens, where the total area of solar collectors makes 17.2 m^2. With this measure 18.1 MWh of natural gas[39] was saved annually and the CO_2 emission was reduced by 3.7 tons.

The Municipality has spent about 15 480 GEL on the conduction of the measure.

Activity R.B2 "Installation of efficient lighting systems" provided taking the measure **RB 2.1. "Installation of fluorescent bulbs in the common areas of residential buildings"** envisaging the replacement of incandescent bulbs by fluorescent ones for lighting 389 m^2 area of stairs cells in common areas of 10-storey building.

The measure has not been implemented in the SEAP-planned format, although the "Sensor lighting" systems were set up. The measure has been undertaken by District Authorities of Tbilisi City Hall in cooperation with the flat owners cooperatives using the co-financing mechanism. All in all 27 113 sensors have been installed during 2010-2014 in the residential buildings. As a result of performed energy efficiency measures 7 869 MWh electric energy has been saved and correspondingly CO_2 emission was reduced by 3 147 tons.

The values of saved energy consumption in the districts of Tbilisi Municipality, resulting from taken measures are given in Table 36. The Table is based upon the norms, established by the EC-LEDS project experts during the preliminary monitoring, according to which the energy saving per each sensor lantern makes on the average 290 KWh/yr.

The information on the number of installed sensor lanterns is provided by Tbilisi district authorities.

Table 36. Saved energy consumption in Tbilisi Municipality districts resulting from carried out measures.

[39] ამ ღონისძიების შედეგად მიღებული დანაზოგის შესაფასებლად გამოყენებულია მზის კოლექტორების დადგმული ჯამური ფართობის მიერ მიღებული ენერგია.

№	District authorities	Number of sensor lanterns	Saved energy MWh/yr.
1	Krtsanisi District Authority	13	3.8
2	Nadzaladevi District Authority	0	0
3	Gldani District Authority	16 646	4 827
4	Didube District Authority	393	114
5	Mtatsminda District Authority	0	0
6	Samgori District Authority	177	51
7	Saburtalo District Authority	0	0
8	Chugureti District Authority	164	48
9	Isani District Authority	8 020	2 326
10	Vake District Authority	1 700	493
	Total	27 113	7 869

The price of installed sensor lantern makes on the average 15 GEL. Therefore, in total 40 695 GEL is spent on the measure, from which 90% is the share of City Hall co-financing, making nearly 36 625 GEL.

Activity RB3. "Renovation of residential buildings" has embraced the measure concerning the substitution of wooden doors and windows with metal-plastic ones in private dwelling houses. According to the assessment based on the EC-LEDS questioning, the total area of these dwellings makes 531 216 m^2. Using the Heat Transfer equation it could be derived that saving equals to 46 853 MWh/yr. and the reduction of GHGs should amount to 9 464 t/yr.

In the frames of **Activity RB4 "Application of renewable energy sources in hot water supply"** during 2010-2014 the solar water heating system with total area 450 m^2 has been mounted in Tbilisi by the LLC "Thermarscenali", and the 50 m^2 solar water-heating system – by the LLC "Solar Energy Georgia" (Levan Kobakhidze). As a result 525 MWh of energy and 106 tons of CO_2 emission have been saved.

Activities RB1 and RB5 were not implemented for residential buildings.

Also the Tbilisi City Hall has executed **Activity RB6 "Low energy consumption building / Pilot project".** In the framework of this measure in the building #29, block #5, the "Temka" micro-district, Tbilisi the City Hall has conducted the complex of measures. In particular, the building was provided with heat supply from the common heat generator, placed at the rooftop of the building. Correspondingly, for accounting the energy supply in each flat the heat meters were installed – total 34 units, costing 400x34=13 600 GEL. In combination with heat generator 23 blocks of vacuum pipe solar collector were assembled at the roof with total area of 95 m^2 aimed at hot water supply.

The double metal-plastic window-frames have been mounted for energy saving in the building divided in 2 blocks external walls, the ceiling and the floor (from bottom side) were thermally insulated.

According to head of building's cooperative, in 2014 winter season the energy saving on heating made 87 MWh, and on hot water supply – 75 MWh/yr.

Thus, resulting from the measure conducted, 162 MWh/yr. of energy and 33 t CO_2/yr. of emissions has been saved.

The fulfilment of this measure costed the Municipality nearly 620 000 GEL.

Measures implemented in other buildings

Activity OB1. Renovation of Tbilisi schools

In Tbilisi 178 public schools are functioning, from which during 2010-2014 central heating system was mounted in 73 public schools. The energy saving is conditioned by high efficiency of modern water-heating boiler (90%) operating on natural gas, that exceeds the efficiency of "Karma" type gas heaters (85%) widely used in municipal buildings. With the adoption in Tbilisi public schools of high efficiency heating systems running on natural gas 205 852 m^3 of gas costing 154 389 GEL were saved annually while the emission of CO_2 was reduced by 352 tons per annum.

Apart from this, wooden doors and windows have been replaced by metal-plastic ones in 171 public schools on the total area of 102 600 m^2. Using the heat transfer equation it could be derived that this measure has resulted in the cutting of energy consumption by 9 050 MWh/r. and of GHG emissions by 1 828 tons annually. The data on saving of energy resources in Tbilisi public schools are given in Table 37.

Table 37. Saving of energy resources in Tbilisi public schools

№	Measure	Natural gas saving, $m3^/yr.$	Energy saving, MWh/yr.	Emission reduction, t/yr.
1	Energy efficient heating system	205 852	(1 482)	352
2	Application of metal-plastic windows	(1 256 944)	9 050	1 828
	Total	1 462 796	10 532	2 180

Besides, during 2010-2014 the energy saving measures were implemented by non-governmental organizations and various companies in Tbilisi. They are described as follows.

Activity OB2. Renewable energy application and energy efficiency pilot projects in different state and commercial buildings, containing the following measures:

OB 2.1. Installation of solar thermal system in Tbilisi #203 public school for hard of hearing children (Energy Efficiency Center and LLC "Solar Energy Georgia").

The following devices have been mounted in total at the #203 public school:

- Solar water-heating system with the total volume 2000 liter;
- 8 units of 200 liter capacity integrated solar water-heating system at the rooftop of education – dwelling building;
- 2 units of 200 liter capacity integrated solar water-heating system at the rooftop of the kitchen.

Table 38. Saving of energy resources in Tbilisi #203 public school

Year	Net saving, KWh/yr.	Emission reduction, t/yr.
2012	9 388	1.9
2013	22 842	4.6
2014	15 461	3.1
Total	47 691	9.6

OB 2.2. Implementation of energy efficiency measures in Tbilisi Baby House (Energy Efficiency Center and LLC "Caucasus Solar").

The following measures have been implemented:

- Thermal insulation of ceiling;

- Replacing windows;
- Substituting existing bulbs by energy efficient lamps;
- Installing water-heating system.

Table 39. Saving of energy resources in Tbilisi Baby House

Measure	m^3/yr.	Net saving KWh/yr.	Emissions reduction t/yr.
Electric energy	-	120 592	16.4
Natural gas	49 876	399 000	80.6
Total	-	519 592	97.0

OB 2.3. Installation of solar water-heating systems in Tbilisi In 2010-2014 the LLC "Caucasus Solar" has installed solar water-heating systems at the total area of 28 m^2.

Table 40. Saving of energy resources by the LLC "Caucasus Solar"

Measures	Net saving KWh/yr.	Emissions reduction t/yr.
Application of solar water-heating system in private hotel	12 600	2.5
Application of solar water-heating system in private clinic	4 200	0.85
Application of solar water-heating system in the "SOS Children's Village"	10 500	2.1
Total	27 300	5.5

OB 2.4. Energy efficiency measure in the JO ANN Medical Center

The implemented at this facility measures are described in Table below:

Table 41. Saving of energy resources in the JOANN Medical Center

Measure	Net saving KWh/yr.	Emissions reduction t/yr.
Thermal insulation of walls and ceiling	551 900	111.5
Installation of a new lighting system	81 800	11.1
Total	633 700	122.6

OB 2.5. Energy efficiency measures in the Georgia Technical University Buildings #3 and #4.

These measures are described in
Table 42.

Table 42. Saving pf energy resources in the GTU buildings #3 and #4

Measure	Net saving KWh/yr.	Emissions reduction t/yr.
Installation of a new lighting system	1 600	0.22

OB 2.6. Energy efficiency measures in the O. Gudushauri National Medical Center

The description of implemented measures is given in Table below.

Table 43. Saving of energy resources in JSC "O. Gudushauri National Medical center"

Measure	Net saving KWh/yr.	Emissions reduction t/yr.
Reconstruction of boiler-room	20 500	4.1
Replacing pumps	62 600	8.5
Installation of a new lighting system	80 334	10.9
Total	163 434	23.5

6. STREET LIGHTING

6.1.Sector overview

In 2010 Tbilisi City Hall has established the company "City of light" Ltd. This is a municipal enterprise which provides the lighting of streets and squares of capital city. The enterprise employs more than 400 people which round-the-clock are supervising the uninterrupted supply of street lighting within the entire limits of the city.

Nowadays by the "City of light" all 10 districts of the capital, left and right embankments of the Mtkvari (Kura) River, all quarters and communities, inner quarter and internal streets are illuminated.

Using the modern lighting system the continuous illumination of the city has become a reality that significantly facilitated moving in the night both of transport and the pedestrians.

Picture 6. Tbilisi at night

It is evident from the Table 44 that the number of public lighting sites from 2009 to 2014 has considerably increase bringing corresponding growth of electric energy consumption for the street lighting in the capital.

It could be derived from the Table that the mean expenditure/consumption of power by one bulb of city lighting system in 2009 was 506 KWh/yr., while in 2014 it became 388 KWh/yr., or the efficiency of lighting has increased by 23%.

Table 44. Number of lanterns in Tbilisi

Years	Number of lanterns/lighting sites (street lighting, decorative illumination sites)	Consumed electric energy, million KWh
2009	92 560	46.8
2014	133 377	51.7

6.2.. Methodology

The amount of emissions from the street lighting sector is calculated via multiplying the quantity of consumed electric energy by the emission factor. In the Tbilisi SEAP the value of emission factor was taken equal to 0.39995 ton of CO_2 on each MWh, calculated applying the CDM methodology. The advantage of this methodology consists of the possibility of its use for the monitoring invariably. In the present Monitoring Report the same emission factor is being used as in the SEAP, while additional calculations are made using the actual average emission factor. For each separate year its value is defined as a ration between the total amount of GHG emissions from the electric energy generation sector and the overall amount of generated electricity. The results of calculating this factor are given in Table 45.

Table 45. Street lighting sector 2014 inventory and its comparison with the GHG emissions baseline scenario

Years	2009	2014
GHG emissions from the electricity generation, tons CO_2 eq.	750	1 080
Total generation of electricity, MWh	8 402	10 371
Mean emission factor, t CO_2 eq./MWh	0.089	0.104

6.3.Street lighting sector 2014 inventory and its comparison with the GHG emissions baseline scenario

In 2014 the consumption of electric energy by the street lighting sector made 51 718 772 KWh, exceeding the projected by SEAP scenario by 4.6%. This discrepancy is caused by the fact that in recent years the addition of bulbs in street lighting sector was performed at a higher rate than it has been provided under the baseline scenario. Using the CDM emission factor emissions from the street lighting sector in 2014 made 20 685 thousand tons CO_2 eq., while using the grid mean emission factor – 5 386 t CO_2 eq. (Table 46).

Below the analysis[40] of alternation in energy efficiency of only street lighting system in Tbilisi is given, which is the major consumer in overall street lighting.

Table 46. Consumption of electricity and GHG emissions from Tbilisi street lighting sector in 2009 and 2014

Parameters	2009 actual	2014 actual	2014 projected by baseline scenario
Electricity consumption, MWh	46 800	51 719	49 431.3
Emissions using CDM factors, t CO_2 eq.	18 718	20 685	19 770.0
Emissions using grid mean factor, t CO_2 eq.	4 178	5 386	5 148.0

The analysis carried out during the process of monitoring has shown that for the examined 5 years (2009-2014) the expenditure of electricity exclusively on street lighting in reality increased by 24%, as the measures planned under SEAP were not implemented precisely according to the schedule and the actual rate of annual increase in the number of lanterns/bulbs has exceeded the planned value.

The monitoring has demonstrated as well that despite the growth in the number of bulbs in the street lighting system by 31% from 2009 to 2014, the installed total capacity has increased by 22%, the duration of illumination – by 2% and the total consumption of electricity – by almost 24%. The average annual consumption by one bulb is reduced by 5.3% (27 KWh). Based upon this it could be derived that the overall efficiency of street lighting has risen. In alternation case, according to 2009 and the nearest years' trend, the consumption would be by 187 665 KWh higher compared to the present value. This assessment is based upon the existing trend of street lighting network development trend, which is discussed below in detail.

As far as the Tbilisi street lighting system is heterogeneous and it consists of different types of bulbs with dissimilar capacity, the average consumption of one bulb does not correctly reflect changes going on in the whole network and using only the average value it is difficult to define the kind of efficiency to deal with. In particular, in case of street lighting network in Tbilisi, it was additionally analyzed what major measures have caused the increased energy efficiency of the network – the substitution of low efficiency bulbs with higher efficiency lamps or the shortening of lighting duration, that could bring serious discomfort to city residents.

As it was mentioned above, in 2014 compared to 2009 the duration of lighting has a little but increased by 2%, hence excluding its role in the rise of network effectiveness.

According to the Tbilisi SEAP information since 2006 the City Hall started to replace in the city lighting the low-efficiency incandescent lamps with more efficient High Pressure Sodium Lamps (HPSL), Compact Fluorescent Lamps (CFLs) and Metal Halide Lamps (MHL). The listed types of bulbs are 1.5-3 times more energy efficient than existing at that time in the network incandescent bulbs.

The comparison between 2009 street lighting networks with the 2014 network has shown that the number of HPSL lamps in 2009 was already 94% of the whole network and just this type of lamps is to be considered as a main determinant of consumption trend in Tbilisi street lighting network. BY 2014 the number of these lamps has not decreased and in contrary has increased by 27% compared to 2009, though in total number of bulbs their share has lowered from 94 to 91%. In the network only 70W and higher capacity lamps of this type are used, constituting 96% of total network capacity. The comparison

[40] This analysis does not concern the immunization of buildings and sites but only of streets, the share of which in 2009 was 82% of total consumption and 92.5% - in 2014.

has shown that in 2014 the number of different capacity sodium lamps has demonstrated notable increase, causing a 28% growth of annual consumption of electricity by this type of lamps and the rise in total share from 93% to 96% between 2009 and 2014.

Relatively significant changes took place in the direction of substituting high capacity lamps with the low capacity bulbs. The number of incandescent bulbs having the lowest energy efficiency and comprising no more than 2% of overall street lighting, has increased from 1.6% in 2009 to 1.9% in 2014 although they cannot seriously affect the total efficiency of the network. However, the summary annual energy consumed by incandescent lamps has decreased by 34%. In this category the number of high capacity lamps (140-500W) has been reduced and the 40W capacity bulbs increased and finally the capacity of incandescent lamps in the network has lowered by 5%.

The number of fluorescent energy efficient bulbs in the network has decreased by 17% and the annual consumption of electricity by this type of bulbs - by 24%. Mainly the number of small lamps has been reduced while the number of big lamps has growth. The consumption of electricity by this type of bulbs does not exceed 1% and similar to incandescent lamps they have no significant impact on the functioning of street lighting system.

The analysis has shown that the main reason of the network efficiency rise is the 80% growth in the number of energy efficient so called "eco-bulbs" within the Tbilisi street lighting system in 2014. New types of lamps have been added to the existing stock as well (14 Diode type for testing, 115 of Metal Halide type). The total number of these "eco-bulbs" and a small quantity of other lamps of new type has reached 2 122 with the total capacity of 102.9 KW, that makes only 5% of total capacity new bulbs added to the entire network. Hence, it comes from this data that the basis of the network is still represented by sodium lamps, the new added capacity of which in 2014 network is 108% (accounting for the 5% decrease in the capacity of incandescent and other less efficient lamps). According to the SEAP mainly it was planned to replace step-by-step existing bulbs by the LED lamps and by the end of 2014 10 000 sodium lamps (with 250 W capacity) were to be substituted with 64 W capacity LED bulbs. At the present stage only 14 LED bulbs are installed, being the object of observation to select most acceptable option. If the network replenishment and lighting of new streets was to be continued at the former pace (sodium lamps with the minimum installed capacity in the existing network equal to 70W per bulb) and the City Hall had no care to gradually introduce new energy efficient "eco-bulbs" in the network, the installation of new 2 122 lamps would increase the network capacity by 148.5 KW, exceeding the present value by 45.5 KW and providing the extra consumption of electricity by (45.5 x 11.3 x 365) = 187 665 KWh. This number is not significant and equals to only 0.4% of overall consumption by the lighting network.

6.4. Measures implemented to reduce GHG emissions from the Tbilisi street lighting sector.

Two alternative measures were considered in the Tbilisi SEAP.

Activity S1. This measure was aimed at the creation of street lighting control center, the main objective of which was to regulate/weaken the intensity of illumination according to outer parameters. This system has not been installed. However, the so called "ecosystems" were mounted which are stabilizing the tension in the network. The purpose of this device is the efficient use of electricity and the increase of its quality index in the network. In 2014 this device has been installed in 150 boxes out of 784 existing boxes, that provided during the 9 months of 2014 a saving of about 983 000 KWh. Using the CDM factor this is equivalent to 393 tons of emission, though applying the network mean emission

factor this value makes 103 tons in CO_2 eq. At the mean time the system is being totally passportized and the installation of same ecosystems in other boxes is under consideration.

Activity S2 (the alternative to S1) – The use of Light Emitting Diodes (LED) for the street lighting. This measure implies the substitution of operating lamps by the LED bulbs. This measure has not been carried out. In 2015 the implementation of pilot projects has started at some streets, among them M. Javakhishvili and Kachinski streets, Baratashvili Bridge, Melikishvili st., the Airport Entrance and Leonidze st. The LED lamps, manufactured by different companies were installed at these streets and observation at them are going on. At the same time, in the current 2015 year the tender on interest expression has been announced, in the frames of which the replacement of 96 000 bulbs with LED lamps is planned for 2016. Under the tender conditions the investment will be enacted by the investor while it will be compensated by the "City of light" using the benefit from the saved energy.

7. GREEN COVER OF TBILISI

7.1. Overview of the sector

In 2010 the Ecology and Greening Urban/City Service has been created at the Tbilisi City Hall with the responsibility to carry out monitoring on the greening of the city and the ecological state of the environment. The orderly functioning of this Service has great importance for the city, especially as the ecological state of the city has seriously worsened since 1990-es. The main reason for this is the growth of transportation sector and the decline of city green cover caused by the degradation of existing parks and forests (diseases, drying, etc.).

The situation is aggravated by the fact that in the green zones of the city the inventory of perennial plants is not carried out and hence it is impossible to assess accurately the dynamics of changes going on in the green zones.

The current Monitoring Report concerns the assessment of the state (as for 2014) of implementing the activities, listed in the 2011 Tbilisi SEAP Greening sector. Based on this assessment the changes in the carbon stocks of city's green cover should be estimated as a result of activities undertaken in 2010-2014 and the annual removal of CO_2 is to be calculated. At the same time the changes in the SEAP green zones were rechecked and specified as well as their general status as a green cover of the city.

For implementing the listed above measures first of all the changes occurred in the areas of Tbilisi green cover were analyzed (as for 2014). In particular, as it is known, the Tbilisi City Assembly under its Resolution #10-24 of 11 September 2009 approved an amendment, according to which the territory of Tbilisi was extended at the expense of its suburbs. In such territories found themselves the villages of Tabakhmela, Tsavkisi, Shindisi and others. As a result the Didgori District has been created, embracing the forested areas of 8 106 ha formerly being under Georgia's Forestry Department. Later on, under the Decree of the Government of Georgia #1 070 of 20 August 2010 these areas were stricken off from the forest fund and transferred into the ownership of Tbilisi self-governing body.

According to the 2006 taxation inventory total volume of woody matter of greenery at the area of 8 106 ha equaled to 560 000 m^3 (69 m^3/ha), in which document kinds were deciduous species (hornbeam, oriental hornbeam) oak, beach, etc.), aged between 60 and 100 years. These naturally originated forest areas are mainly represented with low productivity offshoot groves, featured in

general, due to the anthropogenic impact, by the poor self-restoration ability. These groves require taking measures facilitating the natural renovation processes.

Changes in areas covered by perennial greenery in Tbilisi which took place during 2010-2014 according to districts (including the recreation zones, cemeteries, slopes, lawns, and borders and newly adjoined to the city green zones) are demonstrated in Table 35.

As it could be seen from Table 35 (as of 2014) the area covered by plants equals to 10 436 ha (20% of total area), from which 78% (8 104 ha) comes to forested areas in the vicinities of the city and the remaining 22% (2 332 ha) is assigned to vegetation covered areas of different destination (e.g. parks, squares, cemeteries, lawns, etc.).

As to the changes which took place in the period of 2011-2014, it comes from the Table 35 that during this span the planted areas in some cases have increased and in some cases were reduced, the increase making 21.5 ha and the decrease – 182.5 ha, in total equaling to 161 ha net reduction. The increase in the greening area is caused by the planting activities in various quarters of the city. This aspect in detail is referred to the Table 41, summarizing the activities undertaken in the frames of Tbilisi SEAP greening sector and featuring the status of their implementation.

For a certain period of time the green cover of Tbilisi has experienced a decline caused by different processes, among them: complete logging, cleaning of areas covered by dried plants and caring of cuttings at the adjoined forest areas. In particular, in 2011 at the adjacent to the city territory of 478 ha the dried up, sick and retarded trees were marked out for the conduction of carrying of measures and resulting from this 1 550 trees (nearly 1 085 m^3) were cut down in 2012 and 2 840 trees (about 1 998 m^3) were felled in 2013 and given to the low income population as a firewood.

On the basis of given above data the changes in carbon stock deposited in the Tbilisi greenery for the period of 2011-2014 were calculated, as well as the changes in deposition potential were assessed.

7.2. Methodology and monitoring parameters

Calculations to determine the carbon storage in Tbilisi green cover and its annual uptake were conducted according to IPCC 2003 Good Practice Guideline. Computations were carried out for the "living biomass" including the underground biomass. Carbon stocks in the green cover were calculated separately for the joint canopy groves and fragmentary verdure. The features of biomass decrease as a sequel of trimming and clipping of the trees is also considered in calculations. The applied methodology is same as the methodology used in SEAP, so it is not cited here.

7.3. Activity data and emission factors

The calculations were carried out separately for city plantations (mainly represented by fragmentary verdure) and for forest tracts surrounding the city (where the joint canopy groves of natural origin are dominant).

Different sources were used in calculations for the mentioned two types of green zones. E.g., for the groves around the city the relevant data were taken from the latest (2006, not yet approved) forest arrangement/amelioration materials (e.g. dominant kinds and their reserves – 69 m^3/ha), while as to city greenery (depicted mainly in the fragmentary form), its timber reserves and other data (average age 65 years) were brought from different sources concerning dominant species in the city – tables of growth

rate and reserves[41], etc. As a result the average value has been obtained which makes it possible to assess approximately timber/wood resources per 1 ha of fragmentary greenery (60 m^3).

In the green cover of the city (10 436 ha) the perennial arboreal plants are represented both in the form of joint canopy and fragmentary plantations. Among them joint canopy groves are mainly characteristic at the 8 104 ha territory surrounding the city and the remaining 2 332 ha are covered with fractured verdure. Hence, emission coefficients characterizing both types of plantations were used in calculations.

Namely, from the taxation materials the data on mean annual accretion and plantation reserves were applied in calculations (Table 36), while for obtaining the weighted value of timber specific gravity (D) the data on absolutely dry wood of dominant arboreal plants were used, taken from different scientific references. The values of other factors (BEF_1, BEF_2, R, and CF) were brought from the IPCC supplementary tables, relevant to the region's climate standard values.

Table 47. Changes according to districts in areas covered by perennial greenery in Tbilisi (including recreation zones, cemeteries, slopes and borders and newly adjoined to the city green zones) occurred in 2010-2014

District administration	District area (2014) ha	Area covered with perennial greenery (2010) ha	District area (2014) [42] ha	Main parks entering in the districts	Area covered with perennial greenery (2014) ha	Notes
Vake - Saburtalo	10 248.9	1 150	13 717.5	Vake Park; Mziuri; Red Garden	5 573	3 ha planted in 2011 area at the University high building (increase). 70% pine is dried (2011) at Turtle (Ku) and Lisi Lakes (about 80 ha – decrease). Forested areas decreased by 77 ha. Remaining (1 150-77) = 1 073 ha were added to transferred 4 500 ha, making in total 5 573 ha of plantations.
Gldani-Nadzaladevi	9 928.5	437	9 229.6	Tbilisi Sea park; Kikvidze Park..	455	In 2012 0.5 ha of greener was cut-off in the Kikvadze Park (decrease). At Tbilisi Sea 15 ha (increase in 2014) of difficult kinds of perennial has been planted, as well as 2 ha (increase in 2011-2013) was planted in the Khudadov Forest. Planting activities started (2012) at the Gldani landfill – about
Didgori	9 865.8	**8 106**	After the abolition of the district in 2013 it was divided between the Vake and Mtastminda districts – Tskneti, Bteani and Akhaldaba (4 500 ha) were turned over to Vake and remaining (3 606 ha) covered with greenery area – to Mtastminda district. Entering into the Old Tbilisi administrative area[43]			
Didube-Chugureti	1 588	124	2 265.7	Mushtaid Park; Digomi forest-park	124	-
Old Tbilisi and Isani-Samgori	18 843.4	780	24 986.9	Mtastminda Park; Vere Park; 9 April Park; Deda-ena Park; Botanical Garden.	4 284	At the adjoined area since 2012 the plant-covered plot of 28.4 ha is registered owned by "Medical Group Georgia" Ltd. At this plot 2 ha of forest has been logged for the construction of recreation complex and access road (2 ha decrease)[44]. Around this the remaining area made 780-100-2=678 ha, added to the transferred planted area of 3 606 ha, making in total 4 284 ha of greenery.
Total	50 474.6	**10 597**	50 199.7		**10 436**	Planted area has increased by 21.5 ha, while decreased by 182.5 ha, bringing in total the 161 ha downsizing of greenery area.

[42] http://tas.ge/?p=content&type=6&id=7127
[43]https://www.google.com/search?q=Didgori+district
[44] http://www.safespace-tbilisi.com/

Table 48. Parameters used in calculations and their references

Parameters used in calculations	Values of parameters	
	Fragmentary plantation	Joint canopy plantation
V- Reserves of arboreal plants, m^3/ha[45]	60	69
I_V- Mean annual accretion of arboreal plants, m^3 [46]	1.5	1.7
D- Volume accretion of timber, transfer coefficient to obtain plant's total surface biomass accretion (including canopy)[47]	0.65	0.74
BEF_1- Annual accretion of timber, transfer coefficient to obtain plant's total surface biomass accretion (including canopy) .[48]	1.15	
BEF_2- Transfer coefficient to transform plant surface reserve to its total reserve (including canopy)..[49]	1.3	
R-Ratio between mass of roots and offshoot of the tree.[50]	0.24	
CF- Share of carbon in dry timber.[51]	0.5	

7.4. The 2014 inventory of GHG emissions from Tbilisi greening sector and comparison with baseline scenario.

The calculations have defined the carbon storage in perennial plants of Tbilisi green cover and the annual accretion of carbon stocks. On the basis of changes occurred in Tbilisi green cover (2010-2014) the alternations of carbon storage have been determined (Table 48, Table 49 and Table 50).

Table 49. Changes in biomass reserves occurred in 2010-2014 in Tbilisi green zones

Plants in the green zones	Area/ ha	Status to the beginning of the year				Status to the end of the year		
		Reserve m^3/1ha	Total reserve thousand m^3	Standard annual accretion before the change m^3/ha	Annual accretion after the decrease m^3/ha	Decrease *resulting from natural hazards and trimming) m^3/yr.	Changes in reserves considering the decrease, thousand m^3	Including reserves per 1 ha, m^3/ha
2010								
Fragmentary plants	2 491	60	149.5	1.5	1.5	- -	153.2	61.5
Joint company plants	8 106	69	559.3	1.7	1.7		573.1	70.7
Total	10 597	-	708.8				726.3	-
2011								
Fragmentary plants	2 491	61.5	153.2	1.5	1.04	Total decrease 4 920 m^3 Decrease 1ha 0.46 m^3	155.8	62.5
Joint company plants	8 106	7.7	573.1	1.7	1.24		583.1	71.9

[45] The Telavi Forestry, Inventory Materials, vol. I, 1999.
[46] The Telavi Forestry, Inventory Materials, vol. I, 1999.
[47] "Global Wood Database" http://datadryad.org;
[48] Good Practice Guidance for Land Use, Land Use Change and Forestry, (IPCC 2003),Table 3A1.10;
[49] Good Practice Guidance for Land Use, Land Use Change and Forestry, (IPCC 2003),Table 3A1.10;
[50] Good Practice Guidance for Land Use, Land Use Change and Forestry, (IPCC 2003),Table 3A1.8;
[51] Good Practice Guidance for Land Use, Land Use Change and Forestry, (IPCC 2003).

Total	10 597		726.3				739.0	-
2012								
Fragmentary plants	2 490.5 *	62.5	155.8	1.5	1.39	Total decrease 1 228.8 Decrease 1 ha 0.11 m^3	159.3	64.0
Joint company plants	8 106.0	71.9	583.1	1.7	1.59		596.0	73.5
Total	10 596. 5		739.0				755.3	
2013								
Fragmentary plants	2 490.5	64.0	159.3	1.5	1.3	Total decrease 1 988 Decrease 1 ha 0.2 m^3	162.5	65.2
Joint company plants	8 106.0	73.5	596.0	1.7	1.5		608.1	75.0
Total	10 596.5		755.3				770.6	
2014								
Fragmentary plants	2 490.5	65.2	162.5	1.5	0.77	Total decrease 7 780 Decrease 1 ha 0.73 m^3	164.4	66.0
Joint company plants	8 106.0	75.0	608.1	1.7	0.97		616.0	76.0
Total	10 596.5		770.6				780.4	

** In the beginning of 2012 0.5 ha of green cover was logged in the Kikvidze Park due to the construction of Police Station building.*

Table 50. Carbon stocks in Tbilisi green zones in 2010-2014

Plants in the green zones	Area/ ha	Stock, m^3/1ha	D	BEF_2	(1+R)	CF	Total carbon stocks, thousand tC
2010							
Fragmentary plants	2 491	61.5	0.65	1.3	1.24	0.5	80.2
Joint company plants	8 106	70.7	0.74				341.8
Total	10 597						**422.0**
2011							
Fragmentary plants	2 491	62.5	0.65	1.3	1.24	0.5	81.6
Joint company plants	8 106	71.9	0.74				347.6
Total	10 597						**429.2**
2012							
Fragmentary plants	2 490.5	64.0	0.65	1.3	1.24	0.5	83.5
Joint company plants	8 106.0	73.5	0.74				355.3
Total	10 596.5						**438.8**
2013							
Fragmentary plants	2 490.5	65.2	0.65	1.3	1.24	0.5	85.1
Joint company plants	8 106.0	75.0	0.74				362.6
Total	10 596.5						**447.7**
2014							
Fragmentary plants	2 490.5	66.0	0.65	1.3	1.24	0.5	86.1
Joint company plants	8 106.0	76.0	0.74				367.4
Total	10 596.5						**453.5**

Table 51. Carbon stocks in Tbilisi green zones in 2010-2014

Coverage by plants	Area, ha	Accretion, m^3/ha	D	BE F_1	(1+R)	CF	Total accretion, t C	Reduction biomass due to different causes, m^3	D	BE F_2	CF	Carbon cutback, t C	(Increase-reduction) total accretion, t C
2010													
Fragmentary plants	2 491	1.5	0.65	1.15	1.24	0.5	1 731.7	-	-	-	-	-	9 002.4
Joint company plants	8 106	1.7	0.74				7 270.7						
Total	10 597						**9 002.4**						
2011													
Fragmentary plants	2 491	1.5	0.65	1.15	1.24	0.5	1 731.7	4 920	0.7	1.3	0.5	2 238.6	6 763.8
Joint company plants	8 106	1.7	0.74				7 270.7						
Total	10 597						**9 002.4**						
2012													
Fragmentary plants	2 490.5	1.5	0.65	1.15	1.24	0.5	1 731.3	1 228.8	0.7	1.3	0.5	559.1	8 442.9
Joint company plants	8 106.0	1.7	0.74				7 270.7						
Total	10 596.5						**9 002.0**						
2013													
Fragmentary plants	2 490.5	1.5	0.65	1.15	1.24	0.5	1 731.3	1 988	0.7	1.3	0.5	904.5	8 097.5
Joint company plants	8 106.0	1.7	0.74				7 270.7						
Total	10 596.5						**9 002.0**						
2014													
Fragmentary plants	2 490.5	1.5	0.65	1.15	1.24	0.5	1 731.3	7 780	0.7	1.3	0.5	3539.9	5 462.1
Joint company plants	8 106.0	1.7	0.74				7 270.7						
Total	10 596.5						**9 002.0**						

Table 52. Carbon stocks in Tbilisi green and dynamics of its annual change

	Carbon stocks, thousand TC/yr.				
	2010	**2011**	**2012**	**2013**	**2014**
Carbon accumulated in plants	422.0	429.2	438.8	447.7	453.5
Annual accretion of carbon in plants (considering increase-decrease)	9.0	6.8	8.4	8.0	5.4
Total stocks in plants	**431.0**	**436.0**	**447.2**	**455.7**	**458.9**

As it come from the final Table, carbon stocks, accumulated in the green cover of Tbilisi still demonstrate the annual increase (7.5 thousand t C on the overage), however the tendency of downsizing in annual accretion/sequestration is obvious, caused by lessening of biomass reserves. Annual sequestration in 2014 is decreased by 40% compared to 2010.

Since 2010, in line with the SEAP proposal, annual planting activities were carried out in the city, resulting in the planting of perennials' saplings. In 2010-2014 80 755 trees have been planted, being 45% of planned number, but planting is going on actively. E.g. in autumn of 2014 and in the spring of 2015 all in all 130 000 trees were planted, from which 78 880 trees were purchased, planted and cared for at the expense of 200 472 EUR, and the remaining 51 120 trees were transferred to the City Hall free of charge and planted by volunteers. Concrete numbers of planted trees according to species are given in Table 53.

Table 53. The greenery planted at the territory of Tbilisi in 2010-2014

Species	**Year**					**Total 2010-2014 planted**
	2010	**2011**	**2012**	**2013**	**2014**	
Cypress	3 215	417	1 430	950	4 540	11 052
Linden	400	363	550	800	5 090	8 003
Ash	1 415	200	300	500	3 390	6 405
Maple	1 673	500	450	530	3 490	7 243
Oak	-	-	-	220	2 340	2 660
Pine	3 665	800	2 850	8 300	9 000	25 015
Cedar	1 762	800	1 125	300	6 500	10 487
Paulownia	200	-	-	-	-	200
Poplar	1 810	-	-	10 000	-	11 810
Abies	-	-	50	-	-	50
Spruce	-	-	50	-	-	50
Catalpa	-	-	-	210	50	260
Platanus	-	-	-	150	165	315
Celtis	-	-	-	-	155	155
Total	**14 140**	**3 080**	**6 855**	**21 960**	**34 720**	

7.5.Emissions reduction measures implemented within the Tbilisi greening sector

Table 54. Implementation status of measures taken in Tbilisi greening sector

Sector	Key Actions	Area of Intervention	Policy Instrument	Origin of Action	Responsible Body	Implementation period		Status of Implementation	Estimated Implementation Cost (EUR)	Implementation Cost spent so far (EUR)
						Beginning	Termination			
Greening	**Activity P1: Extension of green zones**									
P1.1	Arranging "Ecological Island"	Other (Greening)	N/A	Local administration	Urban service on ecology and greening	2012	2020	Not implemented yet		0
P1.2	Joining "Mziuri" and the Zoo	Other (Greening)	N/A	Local administration	"-"	2013	2016	Partially		0
P1.3	Enlargement of "Khudadov Forest" up to 63.5 ha	"-"	"-"	"-"	"-"	2014	2018	Partially 2ha		
P1.4	Afforestation of Turtle (Kus) Lake territory 29.2 ha	"-"	"-"	"-"	"-"	2015	2020	Not started		
	Activity P2: Planting of trees									
P2.1	Planting of 160 000 trees	"-"	"-"	"-"	"-"	2012	2015	Planted		
P2.2	Planting 11400 trees in the Khudadovi Forest	Other (Greening)	N/A	Local administration	Urban service on ecology and greening	2011	2011	Planted		
	Activity P3: Management improvement and regulation/control									
P3.1	Forests under the management of Tbilisi City Hall	"-"	"-"	"-"	"-"	2012	2015	Caring of activities are conducted annually		
P3.2	Strict regulation/control of green zones	"-"	"-"	"-"	"-"	2012	2013	Appropriate measures are undertaken		

8. SOLID WASTE

8.1. Overview of the sector

The management of solid residential/domestic waste represents a problem of national, regional and local importance in Georgia.

In recent years the Georgian government has defined the management of solid residential waste as one of the acute problems and in 2006 started to reform the existing system. As a result the purchase of new dump trucks has been undertaken at the national scale, special bunkers were set up in the cities that resulted in the raising of waste collection and city cleaning effectiveness.

In 2007 under the 100% sharing of the Tbilisi government the company "Tbilservice Group" Ltd has been established which provides the cleaning, collection of solid waste, its transportation and disposal, maintenance of operational/closed landfills and downpour collector systems/network within the limits of the city.

In 2011 the Low of Georgia "On the capital city of Georgia – Tbilisi" was approved, according to which the competence of Tbilisi self-government agencies has been determined in the field of city cleaning and waste management.

In 2011 under the assistance of EU the creation of a new legislative basis has begun in the frame of the project "Twinning" devoted to the waste management. As a result a bill has been worked out on "The Code of Waste Management", regulating the problems of waste management, which was approved by Georgia's Parliament in December 2014.[52]

In May 2012 under the legislative amendment[53] the landfill management (waste utilization) all over the territory of Georgia (except Tbilisi and Ajara Autonomous Republic)[54] was transferred from the local self-governing authorities to the central authority. Resulting from this the "Georgian Solid Waste Management Company" Ltd was established, supervised by the Ministry of Regional Development and Infrastructure.

Closed and operating landfills in Tbilisi

Till 2010 Tbilisi was provided by 3 official landfills (Gldani, Lilo and Yagluja SWDSs) owned by Tbilisi Municipality. At present all three landfills are closed.

The operation of Gldani landfill has begun in 1972 and in 2010 it was closed. It was disposed at 8ha of territory and contained more than 5.45 million tons of waste. The thickness of dump layer varied between 8 and 20 meters. The Gldani Landfill served 52% of Tbilisi population.

The Yagluja landfill occupies the area of 5ha in 25km from the center of Tbilisi in the south-eastern direction. Its operation continued from 1985 till 2010. This SWDs has served 48% of city population and comprises more than 2.8 million tons of dump in the layer of 3-20 meter thick.

The functioning of the Lilo landfill proceeded from 1989 to 2004 covering and area of 5ha with 1.8 million tons of waste dumped in 3 to 5 meter thick layer.

[52] https://matsne.gov.ge/ka/document/view/1936322, http://www.momxmarebeli.ge/images/file_727073.pdf, https://matsne.gov.ge/ka/document/view/2676416
[53] The Organic Low of 2005 „On the local self-government"
[54] http://www.waste.gov.ge/index.php?a=main&pid=2&lang=geo

Toll 2010 no one of city's operational landfills was properly guarded – they were not fenced and were easily accessible by animals, creating great risk of the spread of different diseases. Many important problems of environmental protection are just connected with the operation of landfills – no one of them has a groundwater protection or running out water retaining system that caused the contamination of air, soil and surface waters. The landfill gas (LFG) was not collected at the facilities and its emission into the atmosphere was not controlled. At low concentrations this gas is a source of unpleasant odor while at high concentration emissions it can cause explosion or flaring. Moreover, as its main component is methane, featured by sufficiently high value of GWP, these facilities are growing the GHG emissions into the atmosphere.

Picture 7. The view of Gldani and Yagluja landfills

At present the Tbilisi operational SWDS is the Norio landfill. In March 2010 the arrangement of a new landfill has started at the territory of Gardabani Municipality near the village of Norio[55]. Its total area is 83ha and it consists of 4 main sections. In November 2010 only 3 sections (8 ha) were operational with the capacity of dumping daily 30 000 tons of waste, that is enough to provide 100% of city population. The operational span of the Norio landfill is 30-40 years and the potential of waste layer thickness equals to 20-25m. The facility is guarded by fence, the presence of outsiders and animals is prohibited. At the arrival on the landfill dump trucks are weighed by the weighing bridge equipped with the RFID system. Modern technologies are used to dispose the waste and press it by 2-meter layers. The layers are covered with 50 cm deep strata of clay. Draining of wastewater is provided at the landfill as well as collectors of landfill gas are mounted, allowing to prevent the methane flaring. The sorting of waste applying present-day technologies is planned, that should decrease the volume of garbage accumulated at the landfill and increase the share of materials to be processed.

Picture 8. The Norio landfill, 2011

[55] http://www.interpressnews.ge/ge/sazogadoeba/150969-gigi-ugulavam-akhali-nagavsayreli-daathvaliera.html?ar=A

The detailed information on these four landfills is presented in the Table 55.

Table 55. Information about the Tbilisi landfills

Landfill	Opening year	Closing year	Population	Number of dump trucks	Loading of dump trucks, m^3	Type of landfill management	Year of data availability
Gldani	1972	2010	1972-1984-100%; 1985-1989-52%; 1989-2004-42%; 2005-2010–52%		40-12	Covering with soil	2004
Lilo	1989	2004	20%		7	Covering with soil	2001
Yagluja	1985	2010	1985-1988-48%; 1989-2004-38%; 2005-2010-48%		40-7	Covering with soil	2004
Norio	2010	-	100%	7-8 trucks per 1 thousand tons of waste	40-7	Covering with soil; Landfill gas recovery tubes	2011

By 2014 the data on the amount and composition of waste in Tbilisi have been defined more precisely due to the information provided by the Norio landfill administration. On the basis of these statistics the emission of methane generated at the landfill in 2011-2014 has been calculated, during which the actual number of Tbilisi population for this span was used[56].

8.2.Methodology and monitoring parameters

For the monitoring of Tbilisi SEAP prepared in 2011, the IPCC methodology, so called "First order decay" (FOD)[57] method has been used to calculate methane emissions from the city closed and operational landfills. This method has already been applied in calculations conducted in the frames of GHG national inventories and the development of Tbilisi SEAP. The FOD methodology implies the determination of methane emission from Tbilisi one hypothetic landfill without differentiating the existing SWDSs and does not consider the closing periods of landfills. To provide the relatively high precision of FOD methodology the calculation span shell embrace at least 50 years, hence the calculations were performed since 1961, when no official landfill was functioning in Tbilisi. Correspondingly, for the value of MCF, defined by the conditions of SWDS management, in the period of 1961-1971 was taken minimum quantity 0.4 (uncontrolled landfill, Table 47).

In the 2011 Tbilisi SEAP apart of 2009 GHG inventory the projection of methane emission till 2020 from the city landfills is presented for the case if no mitigation measures would be taken (the BAU scenario). The assessment of this scenario was conducted based upon the forecast of such parameters as the

[56] http://geostat.ge

[57] http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf

number of population, amount of waste per capita, etc. In the process of monitoring these projected values were substituted by the actually observed data for 2011-2014 and these data were compared to the projected values.

Parameters used in 2011 Tbilisi SEAP and in the Monitoring Report

Activity data

Number of population generating the waste taken to the landfills[58] is given in Table 56.

Table 56. Comparison between number of population in the SEAP projection and the Monitoring Report

Year	Persons	
	The 2011 Tbilisi SEAP	Monitoring Report
2009	1 136 600	1 136 600
2010	1 152 500	1 152 500
2011	1 165 463	1 162 400
2012	1 178 571	1 172 700
2013	1 191 827	1 171 200
2014	1 205 232	1 175 200

As far as 100% of Tbilisi population's waste is taken to the controlled landfill, the growth of city population comparably will cause the increase in the amount of methane if the per capita generation of waste is not reduced. As it comes from Table 45, the total amount waste in Tbilisi is increasing.

Features of waste generation and disposal processes

Municipal services are regularly taking away domestic waste generated by 100% of Tbilisi population (Table 57).

Table 57. Data on the generation of residential waste in Tbilisi

Year	Total amount of municipal solid waste in the city, tons		Per capita annual amount of waste, kg/person/yr.	
	2011 Tbilisi SEAP	Monitoring Report	2011 Tbilisi SEAP	Monitoring Report
2009	346 356	346 356	304.7	304.73
2010	353 164	353 164	306.4	306.43
2011	299 175	356 123	256.7	306.37
2012	302 539	359 082	256.7	306.20
2013	305 943	362 041	256.7	309.12
2014	309 383	365 000	256.7	310.59

In the SEAP calculations the amount of taken waste in 2001-2010 is based upon actual, observed data, while till 2000 and after 2010 this value is calculated using the number of population and per capita generated amount of waste (the IPCC default value 256 kg/person/yr.). In the Monitoring Report the same approach has been used since 2010, and in 2011-2014 the actual amount of taken waste was specified. On the basis of total amount of taken away waste per capita annually generated waste has

[58] http://geostat.ge

been calculated. According to 2010 data[59] the average amount of waste annually taken to the Tbilisi landfill (population, manufacturers and organizations) equaled to 353 164 tons. Based upon this data (in 2010 the waste was generated by 100% of city population making 1 152 500 persons) per capita amount of waste has been defined (353 164.2/1 192 500 x 1 000 = 36kg). According to 2014 data[60] in Tbilisi annually on the average 1.8 million m^3 (365 000 tons) of waste is generated, being the equivalent of 310.59 kg of waste per capita annually. It could be seen from the Table 58 that per capita amount of waste in Tbilisi annually grows on the overage by 0.38%, finally increasing the methane emissions from the landfills.

Table 58. The amount of solid waste generated by the Tbilisi population

Year	Total amount of municipal solid waste in the city, tons		Per capita annual amount of waste, kg/person/yr.	
	2011 Tbilisi SEAP	Monitoring Report	2011 Tbilisi SEAP	Monitoring Report
2009	346 356	346 356	304.7	304.73
2010	353 164	353 164	306.4	306.43
2011	299 175	356 123	256.7	306.37
2012	302 539	359 082	256.7	306.20
2013	305 943	362 041	256.7	309.12
2014	309 383	365 000	256.7	310.59

Composition of waste

Until recently there were no valuable / precise data in Georgia on the composition of municipal waste and for the Tbilisi former landfills only percentage compositions were available, obtained as a result of episodic investigations (2003, GIZ and 2010 http://geocities-tbilisi.ge/failebi/2388-Introduction.pdf). At present observations on the constitution of waste are carried out on the Norio landfill and in 2014 the data have been presented by the landfill administration for that year, which were used to calculate methane emission from the Norio landfill during the monitoring period (2011-2014). In the period of monitoring calculations for the span of 1961-2009 the same composition of waste was used, as in 2011 Tbilisi SEAP, while for 2010-2013 the interpolation of data on waste structure has been undertaken (Table 59).

Table 59. Interpolation values of waste composition (%) applied in SEAP (2011) and in Monitoring Report

Fraction of waste	Method	Year					
		2009	2010	2011	2012	2013	2014
Organic waste	2011 SEAP	39.0	39.0	39.0	39.0	39.0	39.0
	Monitoring	39.0	44.6	50.2	55.8	61.4	67.0
Garden	2011 SEAP	4.0	4.0	4.0	4.0	4.0	4.0
	Monitoring	4.0	3.2	2.4	1.6	0.8	0.0
Paper	2011 SEAP	34.0	34.0	34.0	34.0	34.0	34.0
	Monitoring	34.0	29.2	24.4	19.7	14.9	10.1
Wood	2011 SEAP	4.0	4.0	4.0	4.0	4.0	4.0
	Monitoring	4.0	3.8	3.6	3.4	3.2	3.0
Textile/Leather	2011 SEAP	3.0	3.0	3.0	3.0	3.0	3.0
	Monitoring	3.0	2.6	2.2	1.8	1.4	1.0
Hygienic waste	2011 SEAP	2.0	2.0	2.0	2.0	2.0	2.0
	Monitoring	2.0	1.8	1.5	1.3	1.0	0.8
Plastics Inert material	2011 SEAP	14.0	14.0	14.0	14.0	14.0	14.0
	Monitoring	14.0	14.8	15.7	16.4	17.3	18.1

[59] Source: The 2011 Tbilisi SEAP
[60] Source: The Norio landfill

Emission Factors

Various factors are used in the process of calculating methane emissions from the solid waste.

Methane Correction Factor (MCF)

The value of MCF depends on the type of landfill – the uncontrolled landfills generate less methane than controlled ones, as in the upper layers of such landfills the most part of waste is decaying in aerobic or oxygen containing conditions accompanied with the creation carbon dioxide. IPCC 1996[61] offers the default values of this factor, which are presented in Table 60.

Table 60. Default values of Methane Correction Factor for different types of landfills

Landfill type/Landfill	MCF
Controlled/Managed[62]	1.0
Controlled thin (waste thickness <5m)[63]	0.5
Uncontrolled thick (waste thickness >5m)	0.8
Uncontrolled thin (waste thickness <5m)	0.4
Uncategorized landfill	0.6
Hypothetic landfill (2011 SEAP/Monitoring Report (1961-1971)	0.4
Hypothetic landfill (2011 SEAP/ Monitoring Report (1972-2014)	1

In 1961-1971 the controlled landfills virtually did not exist in Tbilisi and accordingly the value of 0.4 was taken in calculations. However after 1972 almost 100% of Tbilisi waste was dumped at so called controlled landfills and hence since then the value of MCF is taken equal to 1.

Other parameters

For other parameters such as Degradable Organic Carbon (DOC), Degradable Organic Carbon Fraction (DOCF), Methane Fraction in the landfill gas (F), Oxidation Coefficient (OX), etc. the values used in the SEAP (2011) have been applied.

8.3. The 2014 GHG emissions inventory from the Waste sector and comparison with the baseline scenario

As a result of 2014 GHG inventory in the Waste sector, carried out in the framework of monitoring, it has been established that in this year the methane emissions from solid waste sector made 21.99 Gg, being in CO_2 equivalent 461.79 Gg[64]. In Table 61 the methane emissions from Tbilisi solid waste sector in the monitoring period are given.

Table 61. Methane emissions projected under 2011 Tbilisi SEAP baseline scenario and values specified in the process of monitoring (2009-2014)

Year	Methane, Gg	
	2011 SEAP baseline scenario	Monitoring report
2009	20.04	20.04
2010	20.54	20.54
2011	21.03	21.01
2012	21.13	21.41
2013	21.25	21.74
2014	21.38	21.99

[61] 1996 IPCC Guidelines for National Greenhouse Gas Inventories, http://www.ipcc-nggip.iges.or.jp/public/gl/pdfiles/rusch6-1.pdf
[62] Managed landfill implies the controlled waste disposal site (the placement of waste is performed at specially prepared areas subjected to ventilation where self-flaring is strictly controlled. At the same time waste is being covered, pressed and disposed by layers. GPG, 2000.
[63] 2006 IPCC Guidelines for National Greenhouse Gas Inventories, http://www.ipcc-nggip.iges.or.jp/public/2006gl (p.3.16) (New landfill)
[64] The transfer ratio from methane (CH_4) to carbon dioxide (CO_2) equivalent is taken to be 21 (IPCC, 1996)

The same results in a graphic for are presented in Fig.8.

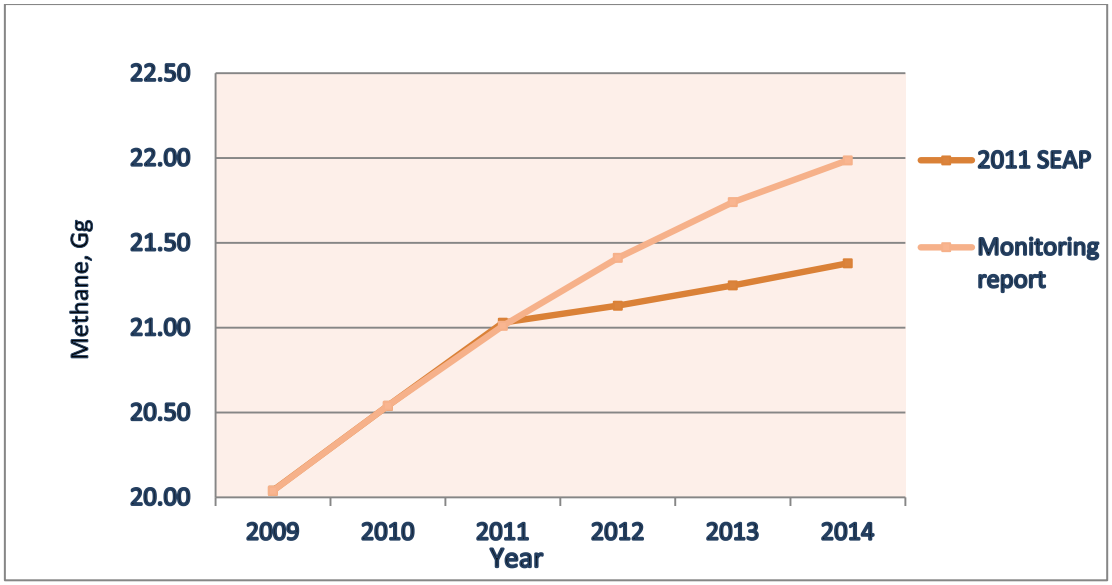


Figure 8. Methane emissions calculated under Tbilisi 2011 SEAP baseline scenario and counted up in the monitoring period (2009-2011)

According to the monitoring results by 2014 methane emissions from the solid waste sector have grown by 9.7% compared to 2009. Emissions counted up in the monitoring period are 2.8% higher than it was projected by the SEAP scenario that is caused by more rapid increase in the amount of solid waste compared to anticipated value (Table 45) and the use of more precisely defined parameters of waste composition (Table 46).

Here it should be mentioned that in 2014 at the Norio SWDS closed section instrumental measurements of the landfill gas have been undertaken by the team of Institute of Hydrometeorology at the Georgian Technical University. The aim of the measurements was the assessment of the amount of biogas or landfill gas generated as a result of anaerobic processes going on at the landfill. The physical properties and chemical composition of gases emitted into the atmosphere were determined. The measurements have shown that during the observation period in 2014 the minimum measured rate of methane generation at the Norio landfill was 3.9 Gg/yr. that coincides with the results of theoretical calculations (3.89 Gg/yr.), though the maximum measured rate was equivalent to 5.5. Gg/yr. that exceeds by 41% calculated theoretical value. Details of the measurements are given in Annex B.

8.4. GHG emissions reduction measures implemented in the Tbilisi solid waste sector

According to 105 data not a single planned measure was implemented from the Tbilisi 2011 SEAP.

Table 62. Status of implementing measures in the solid waste sector

Sector	Key Actions	Area of Intervention	Policy Instrument	Origin of Action	Responsible Body	Period of Implementation		Status of Implementation	Estimated Implementation Cost (EUR)	Implementation Cost spent so far (EUR)
						Starting	Ending			
Municipal landfill (LF)										
Activity LF1	Collection and flaring of gas, generated at the closed landfills (Gldani and Yagluja)	Other (Landfill management)	N/A	Local self-governing authority		2012	2020	Postponed	5,199,308 USD (construction) 72,497 USD annually (operation)	0
Activity LF2	Arrangement of landfill gas flaring system at the new landfill (Norio landfill)	Other (Landfill management)	N/A	Local self-governing authority		2012	2020	Postponed	12 million EURO	0

9. SUSTAINABLE DEVELOPMENT CRITERIA

At the present stage of Tbilisi SEAP current monitoring from the sustainable development criteria only the observation on emissions of air local pollutants has been undertaken and in the frames of this plan the initial assessment of the possible impact on observed concentrations was carried out. At this stage these relations are not established in detail and this work has to be proceeded also in the follow up periods. As far as these are no large polluting enterprises in Tbilisi, along with the contribution of transport in the contamination of local air, the role of the construction sector will be considered in future as well.

Trends of local pollutions concentrations and emissions in Tbilisi.

The major pollutant of atmosphere air in Georgian is motor car exhaust, and as to industrial emissions, after the mounting of high efficiency dust catching filters at the Rustavi and Kaspi cement plants, the Zestaphoni Ferroalloys Facility became the main source of air contamination[65]. In Tbilisi and in some other big cities, concerning the particulate matter (PM), important is the construction sector too. Large amount of transport emissions in the country and especially in sizable cities is conditioned by many factors and their lessening requires complex approach on behalf of different agencies. This includes carrying out such measures as further optimization of traffic management, setting up of permissible age limits for the imported vehicles and their gradual decrease, step by step toughening of norms on motor fuel quality and vehicle exhaust along with their control, the development of electric transportation, etc. All these measures will certainly make important share in downsizing the GHG emissions and, vice versa, measures planned and implemented to reduce the GHG emissions will facilitate the curtailing of exhaust and corresponding cutback of their concentrations in the air.

From the transportation sector the atmospheric air mainly is being polluted by carbon mono oxide (CO), nitrogen (NOx) and sulfur (SO_2) oxides, particular matter (PM) and non-methane volatile compounds (NMVOCs), soot, benz (a)-pyrain and carbon dioxide. In the country's total emissions the major source of nitrogen oxides (NOx) and sulfur dioxide (SO_2) emissions is motor transport. Correspondingly, these pollutants are emitted in those places, where traffic is high-in large cities and transit highways. According to the Ministry of Environment and Natural Resources Protection data the most urgent situation is in Tbilisi, where more than one third of country's transportation is concentrated.

At the country level the state monitoring on air quality is carried out by the National Environmental Agency at the Ministry of Environment and Natural Resources Protection. Up to now the observation on air pollution in Georgia is performed in 5 cities. Tbilisi, Kutaisi, Batumi, Zestaponi and Rustavi. In Tbilisi in total 3 observation boxes are disposed (Tsereteli Ave, Kvinitadze st. Moscow Ave.) together with one background meteorological station in Vashlijvari. Determination of air quality is conducted 3 times a day, in working days (taking of samples is not automated) in Tbilisi the following pollutants are measured: particulate matter (PM), carbon mono oxide (CO), sulfur (SO_2) and nitrogen (NOx) oxides, lead (PB). The data of existing observation network does not describe in full the air quality in the city, but more – the existing state in some of its specific districts.

As it is known the intensity of motor transport exhaust depends on:

- The average age of vehicles and norms of their emissions;
- The technical condition of vehicles and periodic control of their emissions;

[65] http://moe.gov.ge/index.php?sec_id=32&lang_id=GEO

- Norms of fuel quality (e.g. maximum permissible content of sulfur in the fuel), share of vehicles operating on different kinds of fuel (proportion between gasoline and diesel powered motor cars);
- Management of traffic flows, or the frequency of traffic jams and other hold-ups in transportation movement;
- Human awareness, e.g. habits of drivers and pedestrians, number of people using public transport, etc.

The survey undertaken in 2011 by the SYSTRA Company has shown that in process of assessing emissions from the Transportation sector apart of numbering of private cars the age of vehicles driving in the city is important. According to the questioning, the majority of cars is sufficiently old: 39% of the total number of vehicles falls in the 10-14 years category. The next category, embracing 26% of private cars includes age group of 15-19 years. 14% of surveyed private cars fell into the old cars' category, aging 20 years and more and only 6% owners declared that their cars belong to 0-4 years category.

The same results have been obtained in 2014 under the EC-LEDS performed questioning, according to which 90% of vehicles are of 10 years and more age, the majority of which (57%) are manufactured in 1995-2005. This result coincides with the assessment obtained by the Information-Analytical Department of the Ministry of Internal Affairs relevant to the entire country.

The description of public transport fleet and enacted changes are given in detail in the Transportation sector of this Report.

Aiming to protect the atmospheric air from the pollution Georgia's legislation provides the established values of Bounded Tolerance Concentrations (BTC) of harmful substances, which along with the WHO and EU norms are presented in Table 63. It is assumed that if the concentration of pollutants in the air is lower than the given values, the pollution doesn't pose any hazard to human health during the long (even throughout the life) period of impact.

Table 63. Bounded Tolerance Concentrations of the local air pollutants (mg/m³)[66]

Name of harmful substance	BTC according to national legislation (day)	BTC according to WHO	BTC according to EU legislation
PM- particulate matter, total (day)	0.15	-	-
NO_2 – nitrogen dioxide (day)	0.04	0.04 (year)	0.04 (year)
SO_2 – sulfur dioxide (day)	0.05	0.02	0.125
CO – carbon monoxide (da)	3	10 (8 hours)	0.0005
PB – Lead compounds	0.0003	0.0005 (year)	
O_3 – surface layer ozone (day)	0.03	0.12 (8 hours)	

Carbon Monoxide (CO)[67] – is the product of carbon incomplete combustion and its main source are motor cars (produced as a result of fuel incomplete burning due to the insufficient temperature or to the improper air supply system in the internal combustion engine), burning of oil and coal, metallurgical

[66] http://moe.gov.ge/index.php?sec_id=32&lang_id=GEO
[67] https://en.wikipedia.org/wiki/Exhaust_gas#NOx
https://en.wikipedia.org/wiki/European_emission_standards#Emission_standards_for_passenger_cars

production. It is mainly related with the exhaust of >2.5L gasoline powered passenger cars and <3.5L light-duty trucks.

In the internal combustion engines optimal conditions for the burning of fuel are achieved only at the definite working regime, when the engine is loaded at about 75%. The emission of CO at that time is minimal, though in the idle regime of engine operation its concentration in the exhaust is exclusively rising. One of the means to prevent the CO discharge into the atmosphere is the use of special catalyzer mounted in the muffler of the car, which facilitates the oxidation of CO up to CO_2. Unfortunately the major part of vehicle fleet in Georgia has no catalyzers. The diesel engine emits relatively less CO compared to the gasoline engine, but it generates large amount of PM and it exhaust contains more sulfur. The CO lowers the ability of blood to transfer the oxygen. Fig. 9 demonstrates the variation of CO concentration in Tbilisi (in districts where the measurements are conducted).

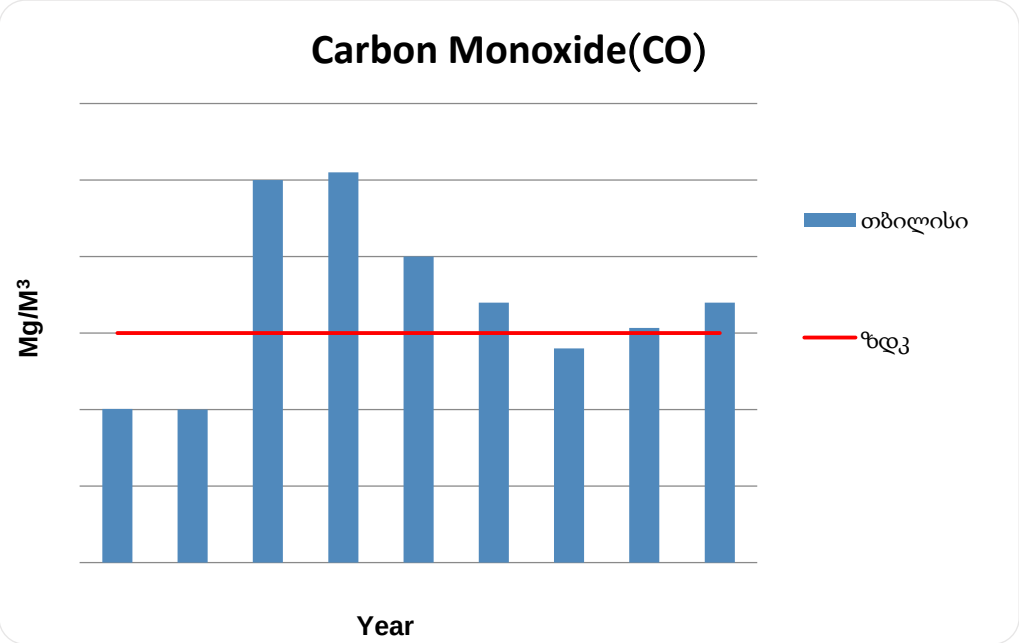


Figure 9. Trend of CO mean annual concentration variation in Tbilisi

Nitrogen oxides (NOx) are produced in the process of combustion at a very high temperature under the conditions of excessive presence of oxygen. Major source of nitrogen oxides emission are motor cars, the residues of natural gas burning, exhaust of thermal power plants, smoke generated as a result of coarse waste burning. In case of Transportation sector it is mainly related with the exhaust of >2.5L gasoline powered passenger cars and ≤15L diesel powered mini-buses.

Nitrogen dioxide present in the air irritates lower part of the respiratory system, especially the lung tissue.

The dynamics of nitrogen dioxide concentration in Tbilisi is shown in Figure 10.

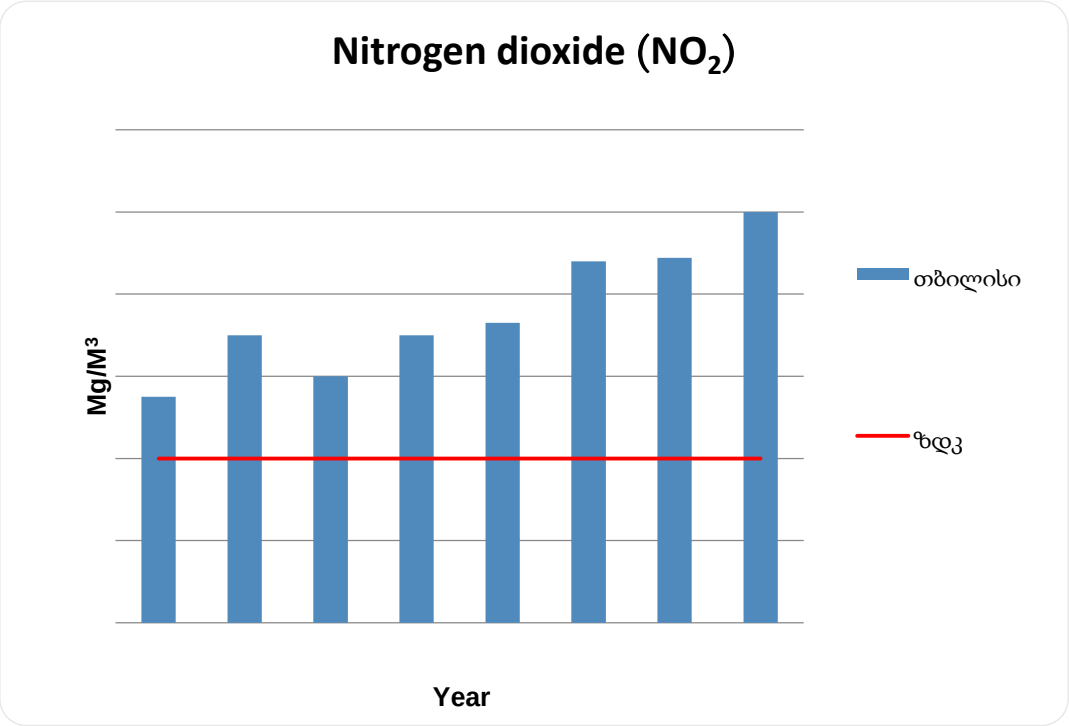


Figure 10. Trend of NO_2 mean annual concentration variation in Tbilisi.

As it comes from the graph, the dynamics of nitrogen dioxide is mainly mounting up despite small variations and after 2006 never has decreased below the bounded concentration.

Sulfur dioxide (SO_2) gets into the atmosphere as a result of burning the fuel, containing sulfur. Its primary source is black oil or coal fired power plants, boilers, metallurgical enterprises and vehicles powered by diesel fuel. The excess concentration of SO_2 in the air causes the irritation of upper part of respirator system. Harmful impact is recorded on the nasopharynx and windpipe mucous membrane.

The concentration of sulfur dioxide in Tbilisi was exclusively high in 2007 (Figure 11), after which it lessened till 2012, but started to grow up again in 2012-2013 and never lowered down to BTC.

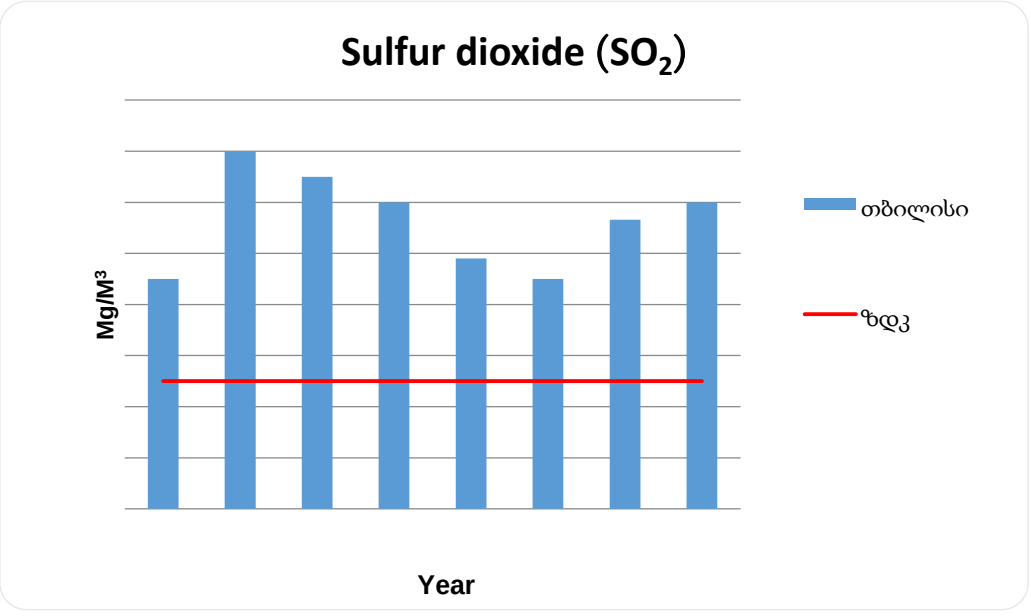


Figure 11. Trend of SO_2 mean annual concentration variation in Tbilisi

Since there are no enterprises in Tbilisi causing the growth in the concentration of this compound, presumably the main pollutant in this case is Transportation sector.

Particulate matter (PM) is another important contaminator of atmospheric air which according to its composition, size and source is very diverse (organic and non-organic).

The major emitters of PM are vehicle powered by diesel engine. In Tbilisi the share of diesel-driven passenger cars is relatively small (7%), though the consumption of diesel is rising quickly both in passenger and commercial cars. Main source of PM in the city are diesel powered mini-buses which comprise main part of vehicle fleet in municipal and commercial transport. Since 2009 their number in public transport has significantly decreased, while has increased in commercial transport.

Particular matter, which often is called simply the dust, gets into the air resulting from fuel combustion and other processes. Main actors in these processes are motor transport. Cement plants, construction and coal burning. While breathing the PM suspended in the air could cause irritation of respiratory organs (branchial tubes, lungs). The PM consists of particles having different size. Smallest particles of dust are: so called PM_{10} – particles having aero dynamical diameter less than 10 micrometer and PM_{25} – particles with the aero dynamical diameter less than 2.5 micrometer. The smaller is the PM pollution for the given period of time are presented in Figure 12.

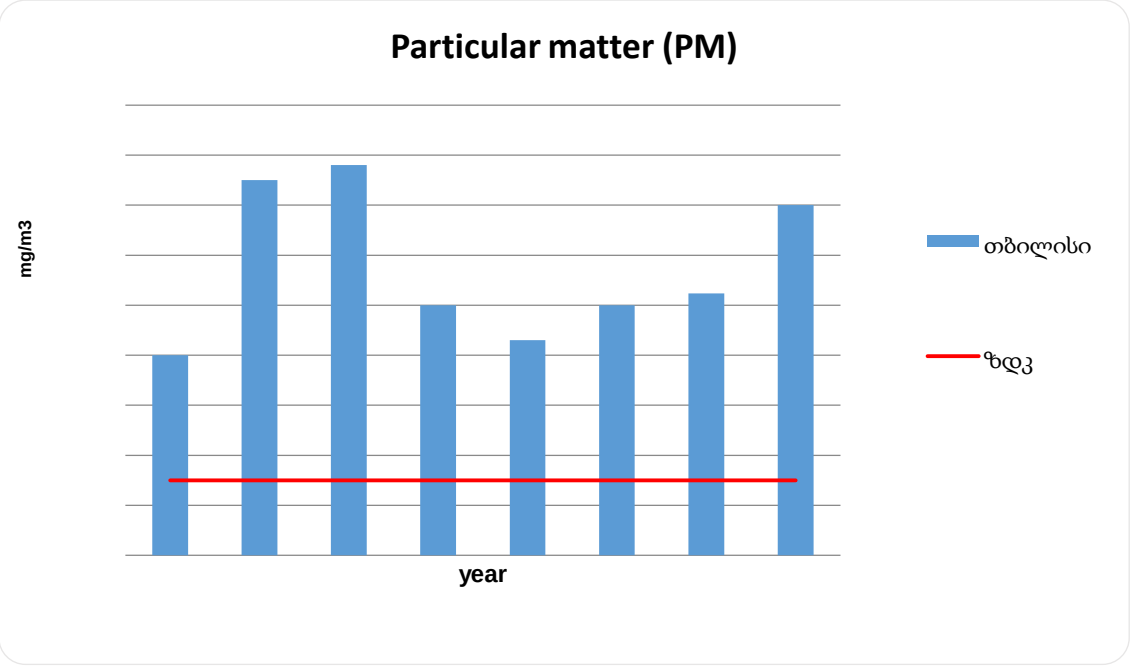


Figure 12. Dynamics of PM mean annual concentration in Tbilisi in 2006-2013.

In general, the exhaust of PM from the transport sector is featured by the rising dynamics, despite the decline in concentration of other admixtures (CO, NOx).

Lead (PB). One of the major sources of environment pollution with the lead is motor transport. The exhaust gases contain in the form of PM lead oxides, chlorides, fluorides, nitrates, sulfates, etc. About 20% of them are sedimenting directly in the vicinity of motor ways.

The major emitters of lead are diesel powered mini-buses.

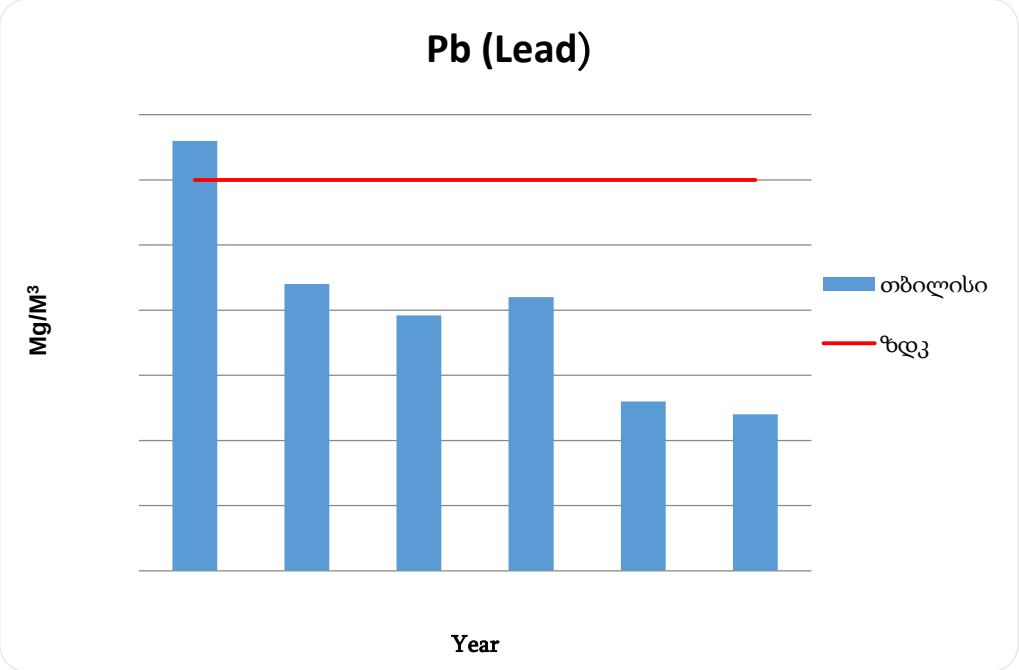


Figure 13. Variation and mean annual concentration of lead in Tbilisi (2006-2013).

The source of getting lead and its compounds into the atmosphere is motor transport exhaust (in case of ethylized gasoline use), metallurgical production, etc. The toxic impact of the lead is manifested on the molecular and cell level, impeding nervous, mental and physical development.

In the frames of current monitoring the trends of local pollutants' emissions have been assessed using the COPERT VI software, which naturally reflects taken or omitted in the transportation sector measures. Emissions of local pollutants and their share in total emission are given in Table 64.

Table 64. Changes in local pollutants' emissions from the Tbilisi Transportation Sector

Type of transport and harmful substance	2009	2014	Change
	Ton (% sum)	Ton (% sum)	%
Passenger cars			
CO	**91 075.61 (90)**	**59 451.55 (90)**	**-35**
Gasoline	90 985.00	59 090.00	-35
Diesel	86.00	139.00	62
Natural Gas	4.61	222.55	4728
NO	**9 584.92 (0.095)**	**6 289.53 (0.1)**	**-34**
Gasoline	9 496.00	6 109.00	-36
Diesel	88.00	136.00	55
Natural Gas	0.92	44.53	4740
NO2	**412.93 (0.4)**	**273.38 (0.4)**	**-34**
Gasoline	402.90	255.00	-37
Diesel	10.00	17.00	70
Natural Gas	0.03	1.38	4500
SO2	**50.10 (0.05)**	**78.80 (0.1)**	**57**

Gasoline	0.00	0.00	0
Diesel	50.10	78.80	57
Natural Gas	0.00	0.00	0
PM	**33.66 (0.03)**	**46.05 (0.07)**	**37**
Gasoline	9.63	6.25	-35
Diesel	24.00	38.50	60
Natural Gas	0.03	1.30	4233
PB	**0.08165 (0.00)**	**0.08246 (0.00)**	**1**
Gasoline	0.07740	0.05027	-35
Diesel	0.00370	0.00582	57
Natural Gas	0.00055	0.02637	4695
Total[68]	101157.30 (100)	66139.39 (100)	-35
Commercial vehicles[69]			
CO	1 287.00 (21)	1 745.00 (21)	36
NO	3 625.00 (58)	4 914.00 (58)	36
NO2	447.00 (7)	607.00 (7)	36
SO2	674.00 (11)	914.00 (11)	36
PM	180.00 (3)	243.00 (3)	35
PB	0.06 (0.001)	0.09 (0.001)	38
Total	6213.06 (100)	8423.09 (100)	36
Public buses and mini-buses			
CO	492.00 (16)	253.00 (15)	-49
NO	1 831.00 (61)	1 034.00 (61)	-44
NO2	227.00 (8)	127.00 (7)	-44
SO2	397.69 (13)	240.00 (14)	-40
PM	77.16 (3)	44.00 (3)	-43
PB	0.04 (0.001)	0.02 (0.001)	-40
Total	3024.89 (100)	1698.02 (100)	-44
Aggregated for all types of transport			
CO	93 649.61 (84)	62 941.55 (81)	-33
NO	15 040.92 (14)	12 237.53 (16)	-19
NO2	1 086.93 (1)	1 007.38 (1)	-7
SO2	1 121.79 (1)	1 232.80 (2)	10
PM	290.82 (0.3)	333.05 (0.4)	15
PB	0.18 (0.00)	0.19 (0.00)	6
Total	110395.25 (100)	76260.50 (100)	-31

[68] This total implies only the emissions of substances listed above and not of all pollutants.
[69] Commercial and public transport is not classified by fuel, as for them primary fuel is diesel and recently only a small portion of them started to use natural gas.

As it could be seen from this Table, the main local contaminant from the transport sector in Tbilisi is carbon oxide (CO), which is loading with 81% in transport overall emissions, as well as with 90% in private passenger cars' subsectors discharge. At the same time, in the public transport (buses and mini-buses) and commercial transport subsectors the leading position is taken by nitrogen oxide (NO) with correspondingly 58 and 61%. In general, the image of Tbilisi Transportation sector is created by private passenger cars, emissions share of which in 2009 was 92% of total release. Despite the following decrease down to 87% (while increasing in absolute value), it retains leading position in 2014. The number of public transport (buses and mini-buses) has also reduced with it contribution in overall emissions from 2.7% down to 2.2%. At this backdrop the role of commercial transport is increasing (both light-duty and heavy-duty trucks), being mainly the consumer of diesel fuel. Though recently this subsector gradually has begun to use natural gas as well.

The share of other contaminations is very small and is not discussed in detail in this Report. However, at certain territories where the concentration of these substances is sufficiently high compared to BTC, they should be discussed more thoroughly and the impact of GHG mitigation measures on these pollutants must be examined. In particular, for a long period of time the content of lead in the fuel was serious problem in Tbilisi. As could be seen on the Figure 5, the concentration of lead in the atmospheric air in 2008 still exceeded the national value of BTC (0,003 mg/m^3), though since 2009 this concentration is gradually decreasing due to the improvement of fuel quality and in some extent its monitoring enacted by the non-governmental sector and some governmental agencies (e.g. Ministry of Environmental and Natural Resources Protection).

As it has been mentioned above, apart from the change in fuel quantity many other factors are significantly affecting these pollutants, among them environment conditions, geography, composition of vehicle fleet, age of cars and kind of fuel consumed. From the Table 2 (passenger cars section) it could be seen that the transfer to the natural gas has seriously increased the carbon oxide emissions from the natural gas and diesel consumption, although as a result of downsizing the total amount of fuel, the emissions of CO from the transport sector for the time being is decreasing. As for the concentration of this substance in the atmosphere, after some decline it started to rise again and even has exceeded the BTC. The discounted trend of carbon emissions is giving hope that its concentration will stabilize. However, this largely depends on the measures which will be taken by the central government and Tbilisi City Hall in the field of Transportation sector and in particular, in the subsector of private passenger cars.

The growth in the number of commercial vehicles operating on diesel has increased the emissions of nitrous oxides from this subsector. It could be seen on the Figure 2, that the concentration of nitrogen oxides in the atmosphere is rising permanently, though the general trend of this impurity in Tbilisi overall transport exhaust is decreasing due to the cutback of gasoline consumption in passenger cars, Despite the twofold rise in the use of diesel both in private and other vehicles, so far it has not reached the amount to increase the share of nitrogen oxides in overall emissions. Thus, it has to be supposed that the revealed trend in concentration is conditioned by those specific locations where the measurements are undertaken, featured with more intense traffic of commercial vehicles and lower potential of ventilation.

10. ANNEX A: EMISSIONS INVENTORY METHODOLOGY IN ENERGY SECTOR

GHG emissions are calculated using a formula adapted for the Intergovernmental Panel on Climate Change (IPCC) methodology Tier 1 sectoral approach for the local level, which is based on actual fuel consumption data:

Carbon Dioxide emissions $_j$ ($GgCO_2$) = $\square\square_i$ {Actual fuel consumption $_{ji}$ (unit) x caloric value of fuel I (MWh1/per unit) x carbon emissions factor (TC/MWh) 1 000 x oxidized carbon portion i} x 44/12,
Where lower index refers to sector and lower index i- type of fuel.
Emissions for other gases with sector approach were calculated via following formula:
GHG emissions (GgGas)=
$\square\square_i$ {Actual fuel consumption $_{ji}$(unit)
x caloric value of fuel (MWh/per unit)
x Gas emissions factor $_{ji}$ (Tgas/MWh/1000}.

The IPCC typical values of carbon emission factors (carbon emission per energy unit) and transfer coefficient (fuel's heat of combustion, i.e. caloricity) have been considered for calculations since 1996. (Table 65).

Table 65: Transfer Coefficients and Carbon Emissions Factors for Different Types of Fuel

Type of Fuel	Unit	Transfer Coefficient (MW/h unit)	Carbon Emission Factor (ton C/MWh)
Gasoline	1000 liters	0.01	0.247
Diesel	1000 tons	0.011	0.267
Liquid Gas	1000 tons	0.013	0.227
Natural Gas	1 million m^3	0.009	0.202
Firewood	1000 m^3	0.002	--

A small portion of carbon in fuel is not oxidized during combustion but most is oxidized later in the atmosphere. It is calculated that non-oxidized carbon is stored indefinitely. Typical values of oxidized carbon recommended by the IPCC and used for 2006-2011 inventory are given in Table 66.

Table 66. Portion of Oxidized Carbon for Different Fuels

Fuel	Portion of Oxidized Carbon
Oil and Oil Products	0.990
Natural Gas	0.995

Different gas emissions factors for the Transport and Buildings sectors are given in Tables below. (Table 67 and Table 68).

Table 67. Methane and Nitrous Oxide Emission Factors for Transport Sector (kg/MWh)

GHG	Gasoline	Diesel	Natural Gas
CH_4	0.072	0.018	0.18
N_2O	0.002	0.002	0.0004

Table 68. Methane and Nitrous Oxide Emission Factors for Buildings Sector (Kg/MWh)

GHG	Natural Gas	Oil Products	Firewood, hazelnut husks
CH_4	0.01944	0.036	1.08
N_2O	0.00036	0.002	0.014

Global warming potential values (GWP) of these gases for converting methane and nitrous oxide into carbon dioxide equivalent are presented in Table 69.

Table 69. Global Warming Potential of Methane and Nitrous Oxide

Gas	Life Expectancy, Yeats	100-year GWP
CH_4	12±3	21
N_2O	120	310

11. ANNEX B: CHANGES INTRODUCED TO UPDATE THE BASELINE SCENARIO

The following amendments have been introduced in the Tbilisi Energy Model baseline scenario for its updating.

1. A number of assumptions on the growth of population and GDP in Tbilisi have been made for the projection of baseline scenario in the Tbilisi SEAP. Correspondingly, the obtained forecasts were based upon these assumptions. However, while developing the 2014 Report the real values of Tbilisi population and GDP growth became known. Consequently, these actual (measured) parameters were put into the model and the revised baseline (BAU) scenario was derived. This adjustment has affected all sectors examined.
2. The following alterations were put into the transportation sector:
   - The motorcycles category has been added, which was not described in 2009;
   - The elasticity of freight turnover growth in commercial transport has been corrected. No activities were taken in this subsector during 2010-2014 and thus its growth is directly proportional to the growth of economy. New elasticity factor relevant to Tbilisi GDP is 1, meaning that the more rises the Tbilisi GDP, the more increases at the same rate the commercial transport's cargo turnover.
3. In the Buildings sector the following changes have been introduced:

- The "Other" (Commercial buildings) category was attached, not examined earlier;
- In the municipal buildings the data on the consumption of firewood and diesel in 2009 has been added and the projected data on gasification till 2014 were substituted with the actual data;
- The projected for 2010-2014 number of natural gas customers in residential buildings has been rectified with actual number and the elasticity of heating with gas was increased from 0.4 to 1 so that forecasts of trends of gas heated areas expansion would become nearer to the reality. The share of population using gas for water heating has increased up to 84% by 2014.

4. In the Street lighting sector the projected for 2014 number of streetlights and their energy intensity features have been replaced by real values.
5. In the Waste sector the projected indexes of population number, amount of waste and its composition were substituted by the actually measured parameters.

Apart from these amendments, the emissions have been recalculated using the electricity emission average factor, causing the alteration of both baseline emissions amount and the future projections.

12. ANNEX C: CAUSES OF ENERGY CONSUMPTION CHANGES IN TBILISI STREET LIGHTING SYSTEM

The analysis[70]of changes in Tbilisi street lighting network causing the alteration of energy consumption by this major energy user is given below.

The analysis carried out during the process of monitoring has shown that for the examined 5 years (2009-2014) the expenditure of electricity exclusively on street lighting in reality increased by 24%, as the measures planned under SEAP were not implemented precisely according to the schedule and the actual rate of annual increase in the number of lanterns/bulbs has exceeded the planned value.

The monitoring has demonstrated as well that despite the growth in the number of bulbs in the street lighting system by 31% from 2009 to 2014, the installed total capacity has increased by 22%, the duration of illumination – by 2% and the total consumption of electricity – by almost 24%. The average annual consumption by one bulb is reduced by 5.3% (27 KWh). Based upon this it could be derived that the overall efficiency of street lighting has risen. In alternation case, according to 2009 and the nearest years' trend, the consumption would be by 187 665 KWh higher compared to the present value. This assessment is based upon the existing trend of street lighting network development trend, which is discussed below in detail.

As far as the Tbilisi street lighting system is heterogeneous and it consists of different types of bulbs with dissimilar capacity, the average consumption of one bulb does not correctly reflect changes going on in the whole network and using only the average value it is difficult to define the kind of efficiency to deal with. In particular, in case of street lighting network in Tbilisi, it was additionally analyzed what major measures have caused the increased energy efficiency of the network – the substitution of low efficiency bulbs with higher efficiency lamps or the shortening of lighting duration, that could bring serious discomfort to city residents.

[70] The analysis does not concern the illumination of buildings and sites, but deals only with street lighting, the share of which in 2009 made 82%, which in 2014 it became 92.5%.

As it was mentioned above, in 2014 compared to 2009 the duration of lighting has a little but increased by 2%, hence excluding its role in the rise of network effectiveness.

According to the Tbilisi SEAP information since 2006 the City Hall started to replace in the city lighting the low-efficiency incandescent lamps with more efficient High Pressure Sodium Lamps (HPSL), Compact Fluorescent Lamps (CFLs) and Metal Halide Lamps (MHL). The listed types of bulbs are 1.5-3 times more energy efficient than existing at that time in the network incandescent bulbs.

The comparison between 2009 street lighting networks with the 2014 network has shown that the number of HPSL lamps in 2009 was already 94% of the whole network and just this type of lamps is to be considered as a main determinant of consumption trend in Tbilisi street lighting network. BY 2014 the number of these lamps has not decreased and in contrary has increased by 27% compared to 2009, though in total number of bulbs their share has lowered from 94 to 91%. In the network only 70W and higher capacity lamps of this type are used, constituting 96% of total network capacity. The comparison has shown that in 2014 the number of different capacity sodium lamps has demonstrated notable increase, causing a 28% growth of annual consumption of electricity by this type of lamps and the rise in total share from 93% to 96% between 2009 and 2014.

Relatively significant changes took place in the direction of substituting high capacity lamps with the low capacity bulbs. The number of incandescent bulbs having the lowest energy efficiency and comprising no more than 2% of overall street lighting, has increased from 1.6% in 2009 to 1.9% in 2014 although they cannot seriously affect the total efficiency of the network. However, the summary annual energy consumed by incandescent lamps has decreased by 34%. In this category the number of high capacity lamps (140-500W) has been reduced and the 40W capacity bulbs increased and finally the capacity of incandescent lamps in the network has lowered by 5%.

The number of fluorescent energy efficient bulbs in the network has decreased by 17% and the annual consumption of electricity by this type of bulbs - by 24%. Mainly the number of small lamps has been reduced while the number of big lamps has growth. The consumption of electricity by this type of bulbs does not exceed 1% and similar to incandescent lamps they have no significant impact on the functioning of street lighting system.

The analysis has shown that the main reason of the network efficiency rise is the 80% growth in the number of energy efficient so called "eco-bulbs" within the Tbilisi street lighting system in 2014. New types of lamps have been added to the existing stock as well (14 Diode type for testing, 115 of Metal Halide type). The total number of these "eco-bulbs" and a small quantity of other lamps of new type has reached 2 122 with the total capacity of 102.9 KW, that makes only 5% of total capacity new bulbs added to the entire network. Hence, it comes from this data that the basis of the network is still represented by sodium lamps, the new added capacity of which in 2014 network is 108% (accounting for the 5% decrease in the capacity of incandescent and other less efficient lamps). According to the SEAP mainly it was planned to replace step-by-step existing bulbs by the LED lamps and by the end of 2014 10 000 sodium lamps (with 250 W capacity) were to be substituted with 64 W capacity LED bulbs. At the present stage only 14 LED bulbs are installed, being the object of observation to select most acceptable option. If the network replenishment and lighting of new streets was to be continued at the former pace (sodium lamps with the minimum installed capacity in the existing network equal to 70W per bulb) and the City Hall had no care to gradually introduce new energy efficient "eco-bulbs" in the network, the installation of new 2 122 lamps would increase the network capacity by 148.5 KW, exceeding the present value by 45.5 KW and providing the extra consumption of electricity by (45.5 x 11.3 x 365) = 187 665 KWh. This number is not significant and equals to only 0.4% of overall consumption by the lighting network.

13. ANNEX D: EMISSION OF METHANE MEASURED AT THE NORIO SWDS[71] IN 2014.

The new Tbilisi landfill is the only SWDS in Georgia designed under the EU standards. The waste at the landfill is placed in the 25m deep cells covered with layers of soil and rammed. By February 2014 one cell has been closed, in which 39 landfill gas (LG) recovery pipes are mounted. To assess the amount of LG generated under the anaerobic processes in the cell of a covered sector of the landfill the instrumental measurements have been under taken. The physical properties of emitted from the collector pipes gases were defined at the site, the outlet of generated gases was determined using the pytoprontel tube and micromanometer, their qualitative and quantitative identification was carried out applying indicator pipes while in the laboratory collected samples of gases were analysed by the chromatographic method. The results are presented in Table 70.

Table 70. Mean annual amount of methane released into the atmosphere from the covered sector of the Norio SWDS (2014)

Parameter	Dimension	Average Value
Hight of the pipe above the surface (h)	m	1.63
Temperature of running out LG (T)	T^0C	48.6
Density of LG (ρ)	Kg/m^3	1.43
Velocity of running out LG (v)	m/s	1.74
Intensity of LG emission (L)	m3/h	39.62
Amount of methane released from one pipe	g/m^3 t/day Gg/yr	349.68 0.33 0.12
Total amount of methane emitted from the covered sector (39 pipes) of the SWDS	Gg/yr	4.73

[71] Mdivani S., Naskidashvili N., Vashakmadze N., Mamulia S., Quatitative assessment of gases emitted from the covered sector of Norio solid residential waste disposal site. Georgian Chemical Journal, 2014, vol. 14, number 1, 155-157 (in Georgian).